NONRESIDENT
TRAINING
COURSE

August 1994

Equipment Operator, Basic

NAVEDTRA 14081

NOTICE

Pages 5-13, AII-2, AII-3, and AII-4 must be printed on a COLOR printer.

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

Although the words “he,” “him,” and “his” are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited.

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

1994 Edition Prepared by
EOC(SCW) John T. Morris

Published by
NAVAL EDUCATION AND TRAINING
PROFESSIONAL DEVELOPMENT
AND TECHNOLOGY CENTER

NAVSUP Logistics Tracking Number
0504-LP-026-7460

Sailor’s Creed

“I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country’s Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all.”

SAFETY PRECAUTIONS

Safety is a paramount concern for all personnel. Many of the Naval Ship's Technical Manuals, manufacturer's technical manuals, and every Planned Maintenance System (PMS) maintenance requirement card (MRC) include safety precautions. Additionally, OPNAVINST 5100. 19C, *Naval Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat*, and OPNAVINST 5100.23B, *NAVOSH Program Manual,* provide safety and occupational health information. The safety precautions are for your protection and to protect equipment.

During equipment operation and preventive or corrective maintenance, the procedures may call for personal protective equipment (PPE), such as goggles, gloves, safety shoes, hard hats, hearing protection, and respirators. When specified, your use of PPE is mandatory. You must select PPE appropriate for the job since the equipment is manufactured and approved for different levels of protection. If the procedure does not specify the PPE, and you aren't sure, ask your safety officer.

Most machinery, spaces, and tools requiring you to wear hearing protection are posted with hazardous noise signs or labels. Eye hazardous areas requiring you to wear goggles or safety glasses are also posted. In areas where corrosive chemicals are mixed or used, an emergency eyewash station must be installed.

All lubricating agents, oil, cleaning material, and chemicals used in maintenance and repair are hazardous materials. Examples of hazardous materials are gasoline, coal distillates, and asphalt. Gasoline contains a small amount of lead and other toxic compounds. Ingestion of gasoline can cause lead poisoning. Coal distillates, such as benzene or naphthalene in benzol, are suspected carcinogens. Avoid all skin contact and do not inhale the vapors and gases from these distillates. Asphalt contains components suspected of causing cancer. Anyone handling asphalt must be trained to handle it in a safe manner.

Hazardous materials require careful handling, storage, and disposal. PMS documentation provides hazard warnings or refers the maintenance man to the Hazardous Materials User's Guide. Material Safety Data Sheets (MSDS) also provide safety precautions for hazardous materials. All commands are required to have an MSDS for each hazardous material they have in their inventory. You must be familiar with the dangers associated with the hazardous materials you use in your work. Additional information is available from your command's *Hazardous Material Coordinator.* OPNAVINST 4110.2, *Hazardous Material Control and Management,* contains detailed information on the hazardous material program.

Recent legislation and updated Navy directives implemented tighter constraints on environmental pollution and hazardous waste disposal. OPNAVINST 5090.1A, *Environmental and Natural Resources Program Manual*, provides detailed information. Your command must comply with federal, state, and local environmental regulations during any type of construction and demolition. Your supervisor will provide training on environmental compliance.

Cautions and warnings of potentially hazardous situations or conditions are highlighted, where needed, in each chapter of this TRAMAN. Remember to be safety conscious at all times.

CONTENTS

CHAPTER **PAGE**

1. Engine Systems.. 1-1
2. Power Train 2-1
3. Chassis Systems 3-1
4. Electrical and Hydraulic Systems .4-1
5. Rules of the Road. 5-1
6. Transportation Operations 6-1
7. Tractor-Trailers and Dump Trucks 7-1
8. Forklifts 8-1
9. Front-end Loaders, Excavators, and Ditchers 9-1
10. Graders and Scrapers 10-1
11. Dozers and Rollers 11-1
12. Cranes and Attachments 12-1
13. Rigging 13-1
14. Miscellaneous Equipment 14-1
15. Earthwork Operations. 15-1
16. Paving Operations and Equipment 16-1

APPENDIX

I. Glossary of Terms and Acronyms AI-1
II. International Signals and Road Signs. AII-1
III. The Metric System and Conversion Tables. AIII-1
IV. Hand Signals AIV-1
V. References V-1

INDEX INDEX-1

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

http://courses.cnet.navy.mil

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

http://www.advancement.cnet.navy.mil

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n314.products@cnet.navy.mil
Phone: Comm: (850) 452-1001, Ext. 1826
DSN: 922-1001, Ext. 1826
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC (CODE N314)
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC (CODE N331)
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you will receive retirement points if you are authorized to receive them under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 18 points. These points will be credited in units as follows:

Unit 1 - 12 points upon satisfactory completion of assignments 1 through 8.

Unit 2 - 6 points upon satisfactory completion of assignments 9 through 12.

(Refer to *Administrative Procedures for Naval Reservists on Inactive Duty,* BUPERSINST 1001.39, for more information about retirement points.)

COURSE OBJECTIVES

This course provides the basic information required for Advanced Equipment Operators to perform the duties and responsibilities in the following positions: Transportation Supervisor; Air Detachment Equipment Supervisor; Crane Crew Supervisor; Project Supervisor; Quarry Supervisor; Crusher Supervisor; Asphalt Plant Supervisor; Well Drilling Supervisor.

Student Comments

Course Title: *Equipment Operator, Basic*

NAVEDTRA: 14081 **Date**: ______

We need some information about you

Rate/Rank and Name: ______ SSN: ______ Command/Unit ______

Street Address: ______ City: ______ State/FPO: ______ Zip ______

Your comments, suggestions, etc:

Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00)

CHAPTER 1

ENGINE SYSTEMS

To become a professional Equipment Operator, you must understand the principles of operation of automotive and construction equipment. This chapter covers the basic principles of engines, fuel systems, air induction systems, lubrication systems, and cooling systems on the equipment used by the Navy and the Naval Construction Force (NCF).

INTERNAL COMBUSTION ENGINES

An engine is a device that converts heat energy into mechanical energy to perform work. An internal combustion engine is any engine in which fuel is burned within its body (fig. 1-1). The combustion that occurs within the cylinders produces energy. This energy moves the parts of the engine that drives the equipment.

Air and fuel are two elements needed to produce heat energy in an engine. Oxygen in the air is evenly mixed with the fuel and is vaporized. This mixture allows for quick and even burning. The chemical process that occurs when the air and fuel mixture in the cylinder is ignited is known as combustion.

An engine uses both reciprocating motion and rotary motion to transmit energy. Four parts of the engine work together to convert reciprocating motion into rotary motion. These four parts are as follows: a cylinder, a piston, a connecting rod, and a crankshaft (fig. 1-2). The piston and cylinder are matched parts, fitted closely to allow the piston to glide easily with little clearance at the sides within the cylinder. The top of the cylinder is closed and has a space for the combustion chamber. The connecting rod transmits the up-and-down motion of the piston to the crankshaft. The crankshaft

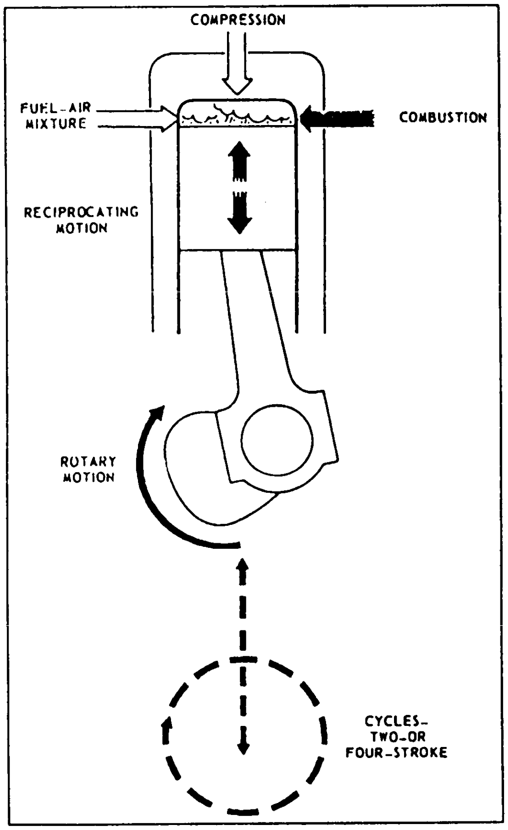


Figure 1-1.-Basic elements of an engine.

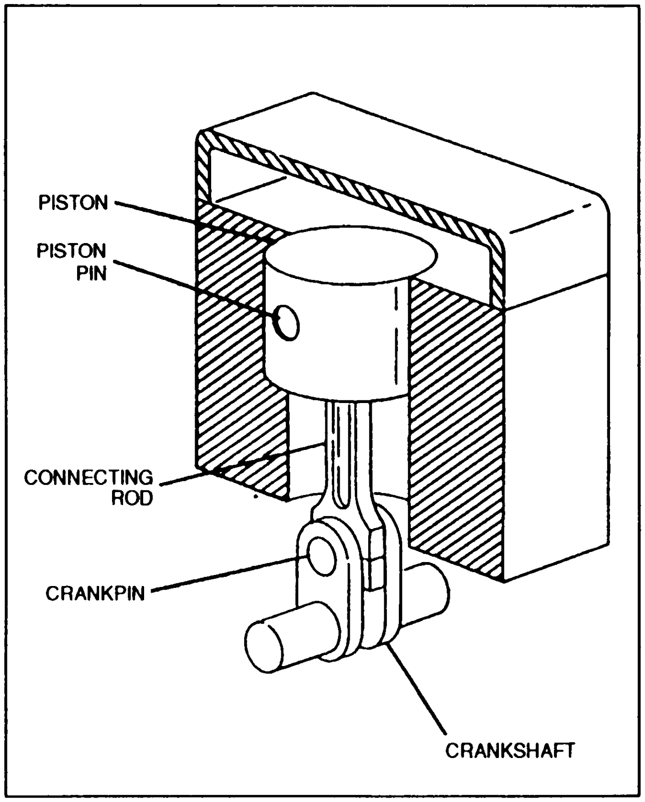


Figure 1-2.-Piston and crankshaft.

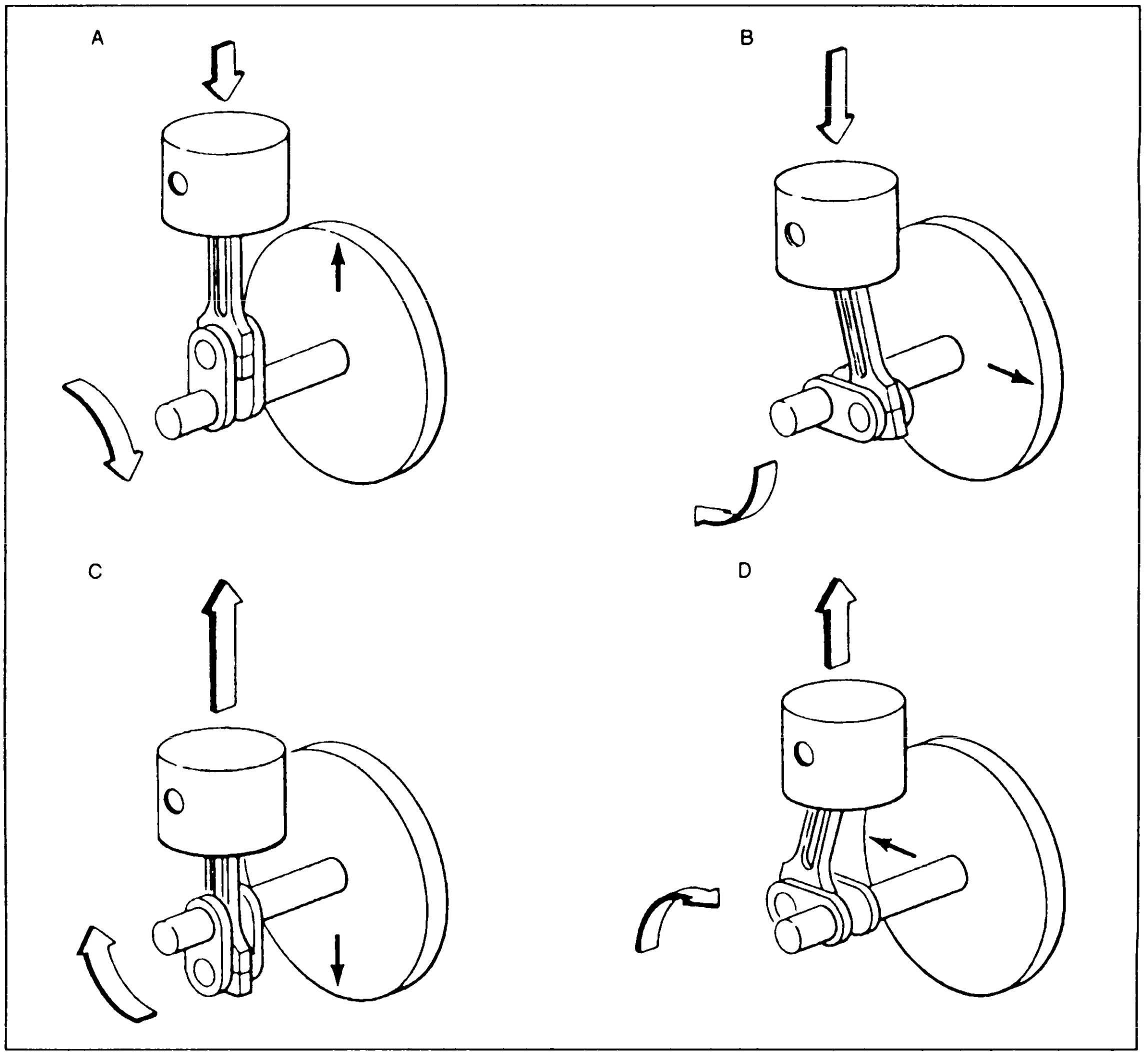


Figure 1-3.—Piston to crankshaft relationship.

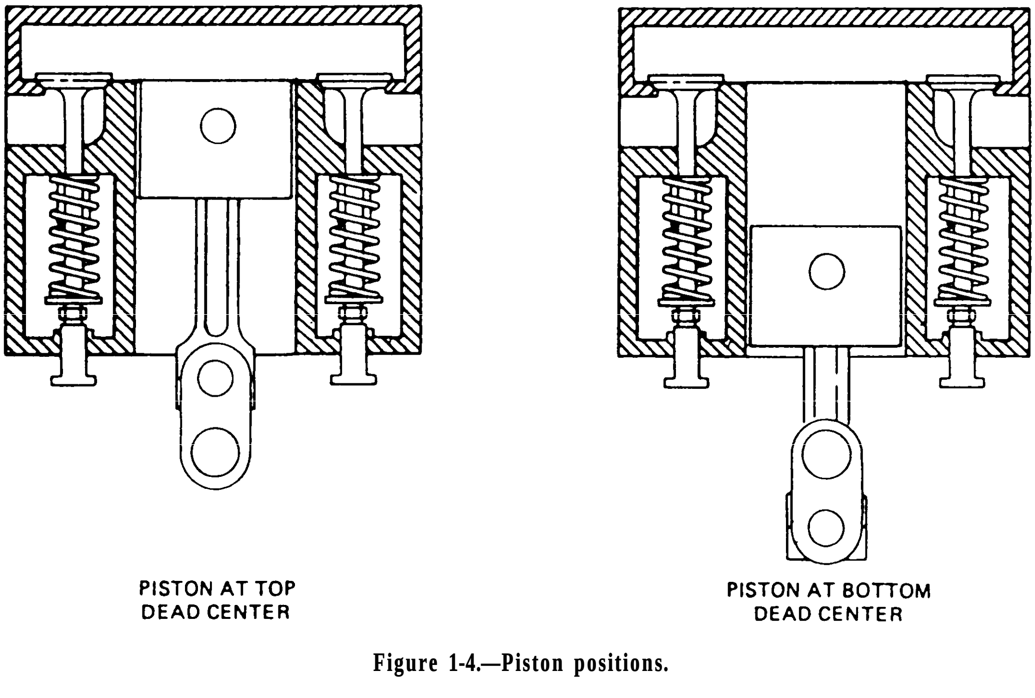

PISTON AT TOP DEAD CENTER
PISTON AT BOTTOM DEAD CENTER

Figure 1-4.—Piston positions.

has a section offset from the center line of the shaft so that it "cranks" when the shaft is turned (fig. 1-3).

ENGINE CYCLE

When the piston is at the highest point in the cylinder, it is in a position called top dead center (TDC). When the piston is at its lowest point in the cylinder, it is in a position called bottom dead center (BDC) (fig. 1-4). As the piston moves from top to bottom or from bottom to top, the crankshaft rotates exactly one half of a revolution. Each movement of the piston from top to bottom or from bottom to top is called a stroke; therefore, the piston completes two strokes for every full crankshaft revolution.

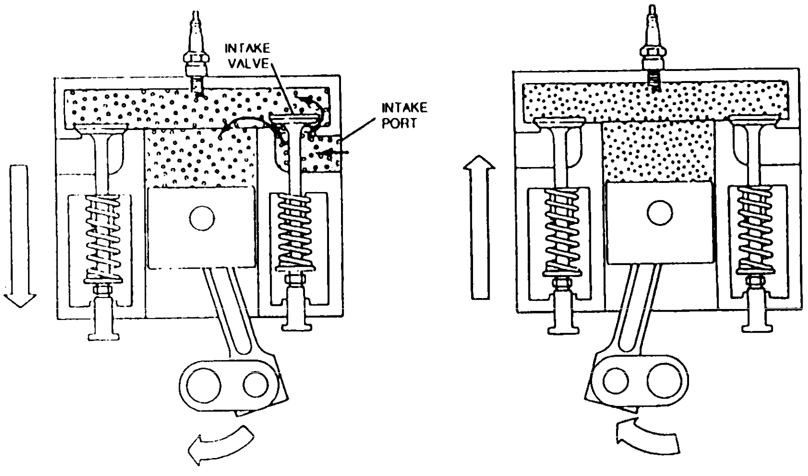
For an engine to operate, the following sequence of events must occur:

1. **INTAKE:** A combustible mixture is pulled into the cylinder.
2. **COMPRESSION:** The combustible mixture is compressed into a smaller space.
3. **POWER:** The compressed combustible mixture is ignited causing it to expand, producing power.
4. **EXHAUST:** The burnt gases are removed from the cylinder.

The engine repeats this sequence of events over and over again to produce sustained power. One complete series of these events in an engine is called a cycle. Engines have either a four-stroke cycle or a two-stroke cycle; most engines operate on the four-stroke cycle.

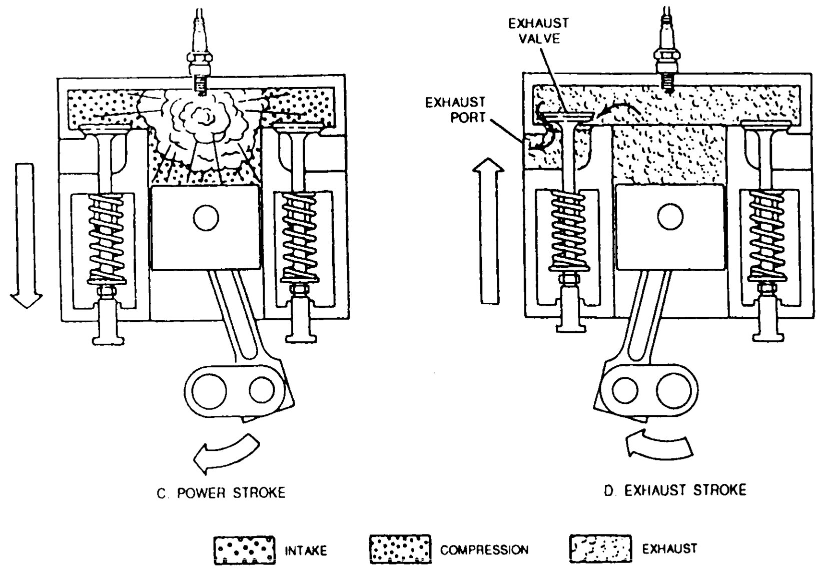
Four-Stroke Cycle Gasoline Engine

In the four-stroke cycle gasoline engine, there are four strokes of the piston in each cycle: two up and two down (fig. 1-5). The four strokes of a cycle are as



A. INTAKE STROKE

B. COMPRESSION STROKE



C. POWER STROKE

D. EXHAUST STROKE

Figure 1-5.—Four-stroke cycle operation.

follows: intake, compression, power, and exhaust. A cycle occurs during two revolutions of the crankshaft.

INTAKE STROKE. — The intake stroke begins at top dead center, and as the piston moves down, the intake valve opens. The downward movement of the piston creates a vacuum in the cylinder, causing a fuel and air mixture to be drawn through the intake port into the combustion chamber. As the piston reaches bottom dead center, the intake valve closes.

COMPRESSION STROKE.— The compression stroke begins with the piston at bottom dead center and rising up to compress the fuel and air mixture. Since both the intake and exhaust valves are closed, there is no escape for the fuel and air mixture, and it is compressed to a fraction of its original volume. At this point, the fuel and air mixture is ignited.

POWER STROKE.— The power stroke begins when the fuel and air mixture is ignited, burns and expands and forces the piston down. The valves remain closed so that all the force is exerted on the piston. The power stroke ends as the piston reaches bottom dead center.

EXHAUST STROKE.— The exhaust stroke begins when the piston nears the end of the power stroke and the exhaust valve is opened. As the piston moves upward towards top dead center, it pushes the burnt gases, resulting from the ignition of the fuel and air mixture, out of the combustion chamber and through the exhaust port. As the piston reaches top dead center, ending the exhaust stroke, the exhaust valve closes, and the intake valve opens to begin the intake stroke for the next cycle.

Four-Stroke Cycle Diesel Engine

The four-stroke diesel engine is similar to the four-stroke gasoline engine. They both follow an operating cycle that consist of intake, compression, power, and exhaust strokes. They also share similar systems for intake and exhaust valves. The components of a diesel engine are shown in figure 1-6.

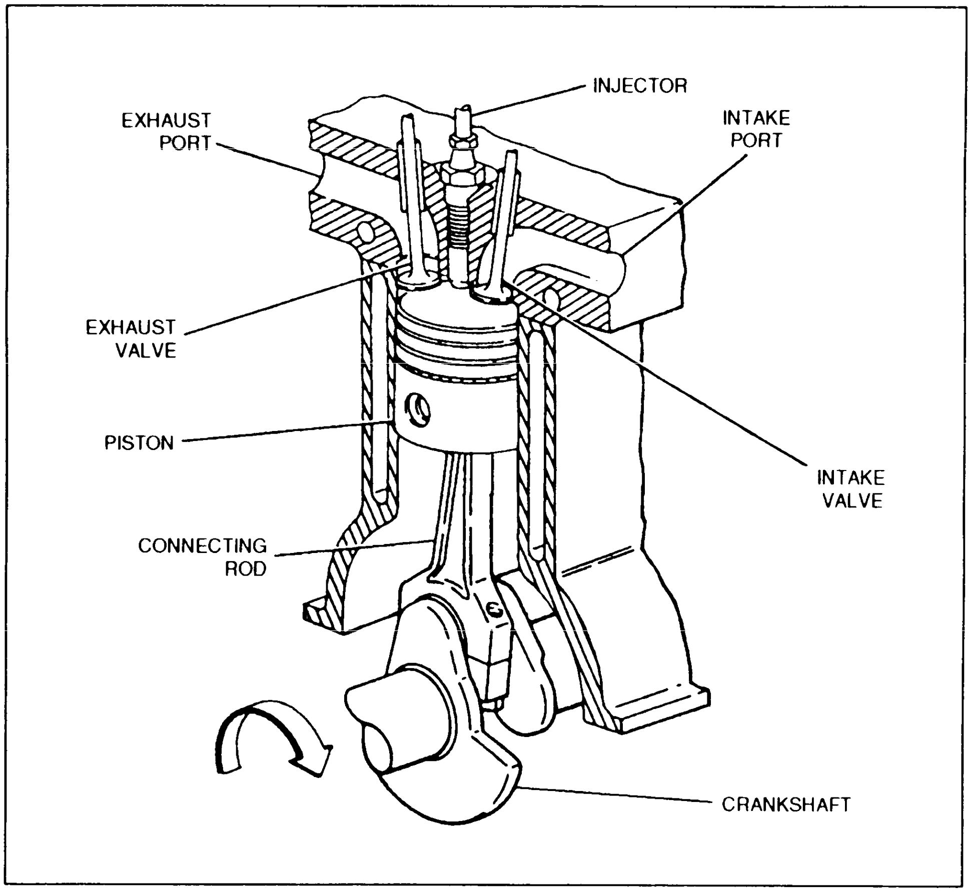


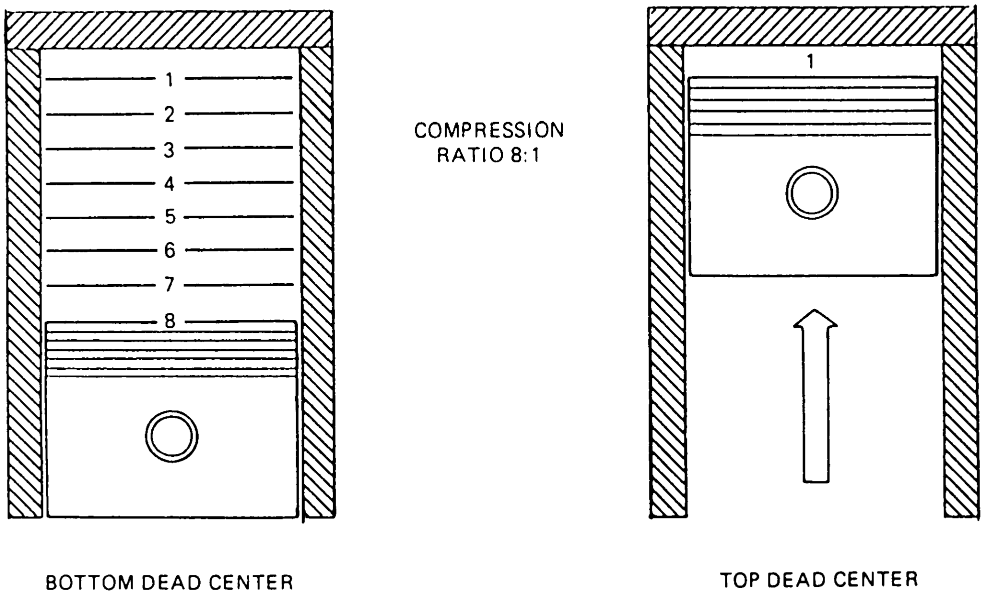
Figure 1-6.—Four-stroke cycle diesel engine.

The primary differences between a diesel engine and a gasoline engine are as follows:

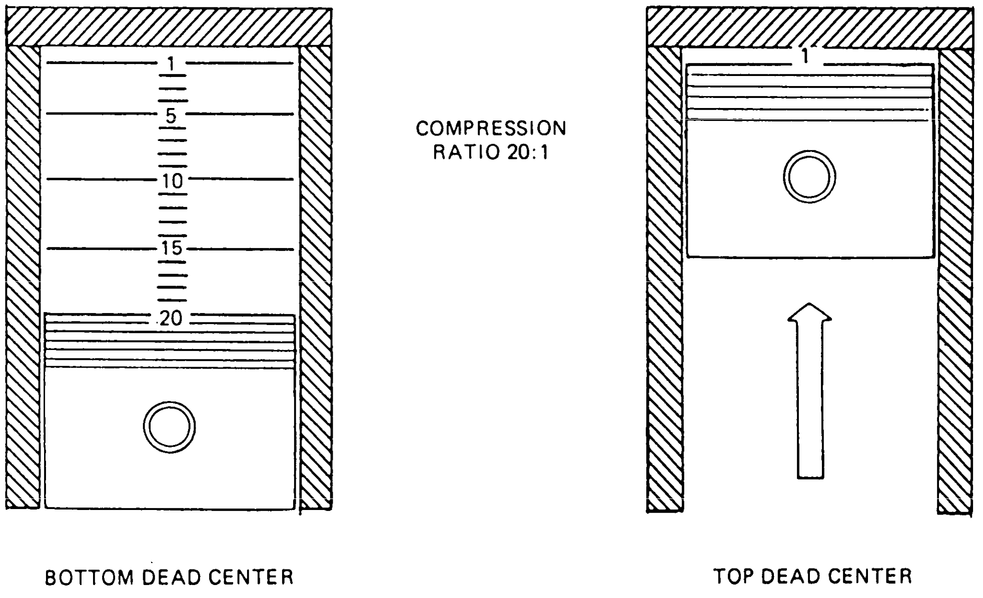
1. The fuel and air mixture is ignited by the heat generated by the compression stroke in a diesel engine versus the use of a spark ignition system on a gasoline engine.

2. The fuel and air mixture in a diesel engine is compressed to about one twentieth of its original volume, while in a gasoline engine the fuel and air mixture is only compressed to about one eighth of its original volume. The diesel engine must compress the mixture more tightly to generate enough heat to ignite the fuel and air mixture. The contrast between the two engines is shown in figure 1-7.

3. The gasoline engine mixes the fuel and air before it reaches the combustion chamber. A diesel engine takes in only air through the intake port. Fuel is put into the combustion chamber directly through an


1
2
3
4
5
6
7
8
COMPRESSION RATIO 8:1
1
BOTTOM DEAD CENTER
TOP DEAD CENTER

GASOLINE ENGINE


1
5
10
15
20
COMPRESSION RATIO 20:1
1
BOTTOM DEAD CENTER
TOP DEAD CENTER

DIESEL ENGINE

Figure 1-7.—Diesel and gasoline engines compression strokes.

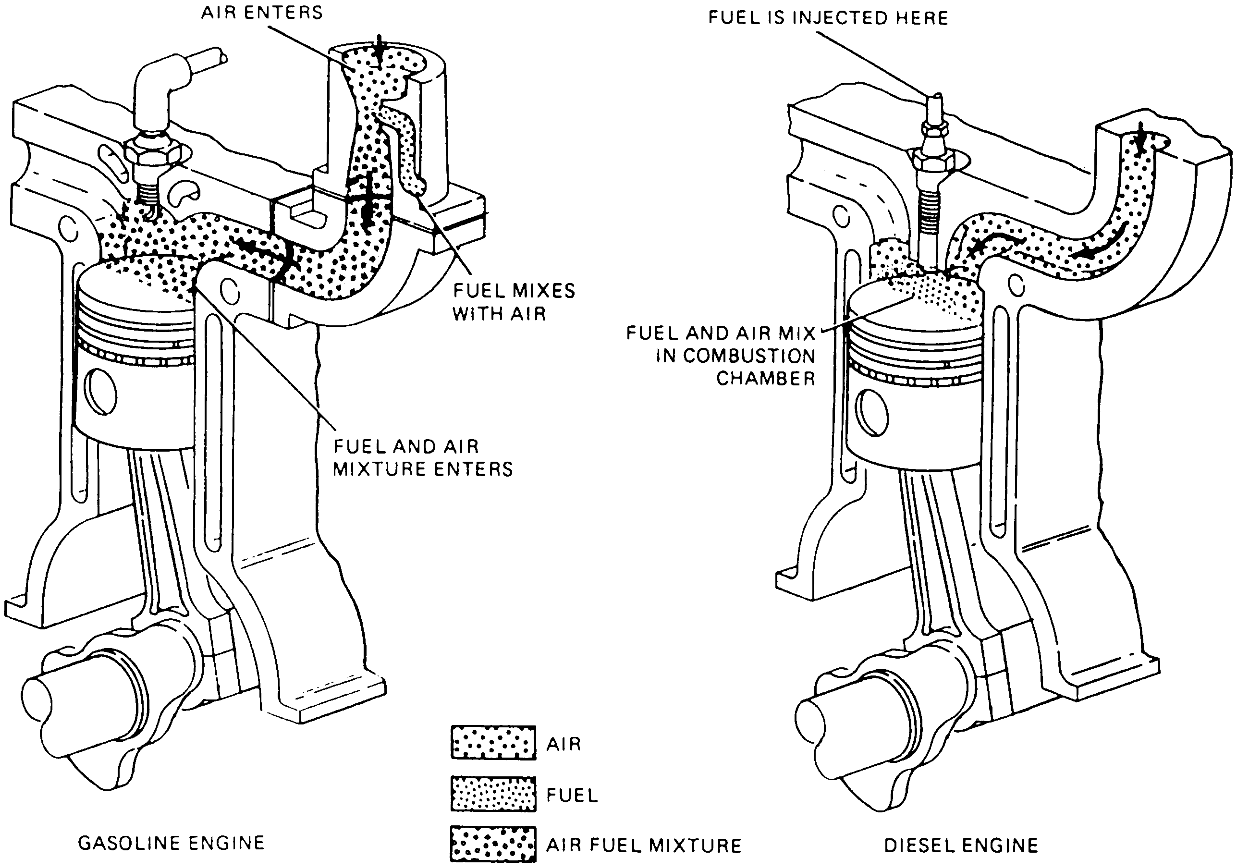

AIR ENTERS
FUEL IS INJECTED HERE
FUEL MIXES WITH AIR
FUEL AND AIR MIX IN COMBUSTION CHAMBER
FUEL AND AIR MIXTURE ENTERS
AIR
FUEL
AIR FUEL MIXTURE
GASOLINE ENGINE
DIESEL ENGINE

Figure 1-8.-Diesel and gasoline engines intake strokes.

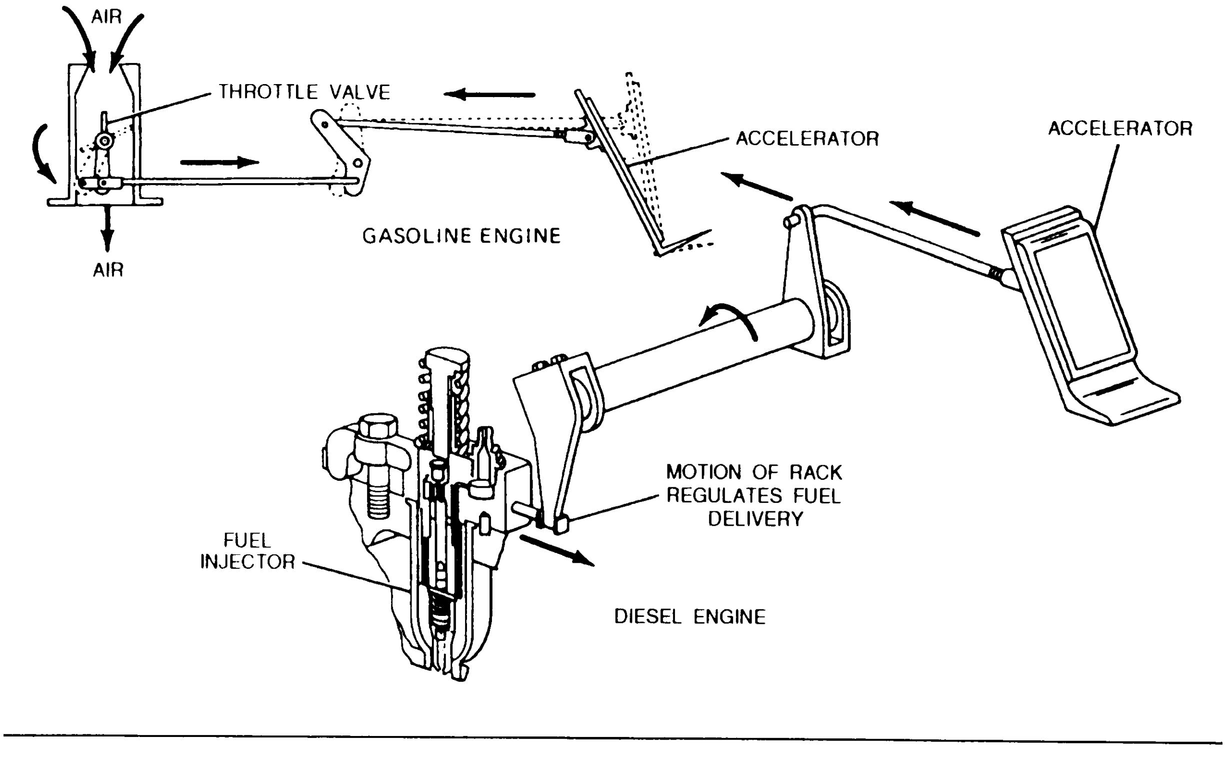

AIR
THROTTLE VALVE
ACCELERATOR
ACCELERATOR
AIR
GASOLINE ENGINE
MOTION OF RACK REGULATES FUEL DELIVERY
FUEL INJECTOR
DIESEL ENGINE

Figure 1-9.—Diesel and gasoline engines regulation of power.

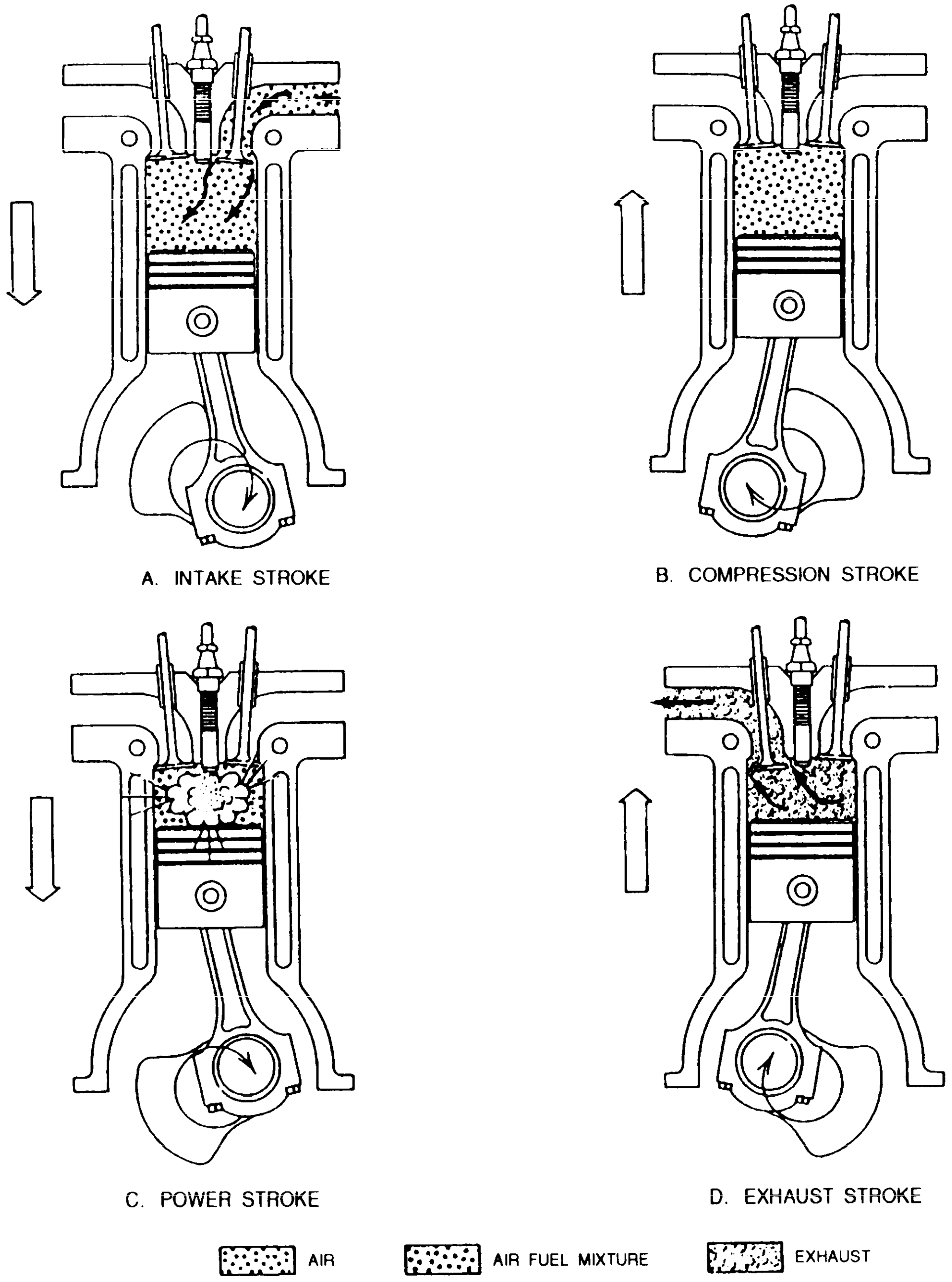
injection system. The air and fuel then mix in the combustion chamber (fig. 1-8).

4. The engine speed and the power output of a diesel engine are controlled by the quantity of fuel admitted to the combustion chamber. The amount of air is constant. On the gasoline engine, the speed and power output is regulated by limiting the air and fuel mixture entering the engine (fig. 1-9).

A diesel engine is much more efficient than a gasoline engine, such as the diesel engine does not require an ignition system due to the heat generated by the higher compression, the diesel engine has a better fuel economy due to the complete burning of the fuel, and the diesel engine develops greater torque due to the power developed from the high-compression ratio.

The strokes that make up the four-stroke cycle of a diesel engine follow.

DIESEL ENGINE INTAKE STROKE.— The piston is at top dead center at the beginning of the intake stroke, and, as the piston moves downward, the intake valve opens. The downward movement of the piston draws air into the cylinder, and, as the piston reaches bottom dead center, the intake valve closes (fig. 1-10, view A).


A. INTAKE STROKE

B. COMPRESSION STROKE

C. POWER STROKE

D. EXHAUST STROKE

Figure 1-10.—Four-stroke cycle diesel engine.

DIESEL ENGINE COMPRESSION STROKE.— The piston is at bottom dead center at the beginning of the compression stroke, and, as the piston moves upward, the air compresses. As the piston reaches top dead center, the compression stroke ends (fig. 1-10, view B).

DIESEL ENGINE POWER STROKE.— The piston begins the power stroke at top dead center. The air is compressed to as much as 500 psi and at a compressed temperature of approximately 1000°F. At this point, fuel is injected into the combustion chamber and is ignited by the heat of the compression. This begins the power stroke. The expanding force of the burning gases pushes the piston downward, providing power to the crankshaft. The diesel fuel will continue to bum through the entire power stroke (a more complete burning of the fuel) (fig. 1-10, view C). The gasoline engine has a power stroke with rapid combustion in the beginning, but little to no combustion at the end.

DIESEL ENGINE EXHAUST STROKE.— As the piston reaches bottom dead center on the power stroke, the power stroke ends and the exhaust stroke begins (fig. 1-10, view D). The exhaust valve opens, and, as the piston rises towards top dead center, the burnt gases are pushed out through the exhaust port. As the piston reaches top dead center, the exhaust valve closes and the intake valve opens. The engine is now ready to begin another operating cycle.

Multifuel Engine

The multifuel engine (fig. 1-11) is basically a four-stroke cycle diesel engine with the capability of operating on a wide variety of fuel oils without adjustment or modification. The fuel injection system is equipped with a device called a fuel density compensator that varies the amount of fuel to keep the power output constant regardless of the type fuel being used. The multifuel engine uses a spherical combustion chamber (fig. 1-12) that aids in thorough fuel and air mixing, complete combustion, and minimizes knocks.

NOTE: Because of environmental pollution controls and the development of more efficient diesel engines, the multifuel engine is being phased out.

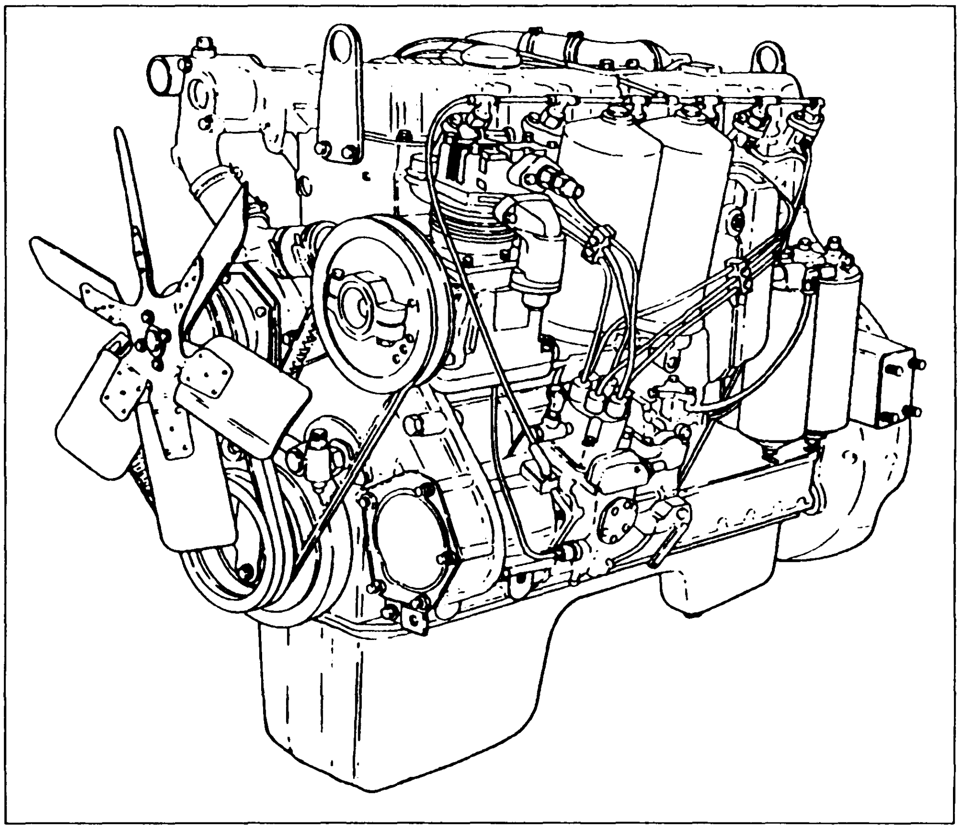
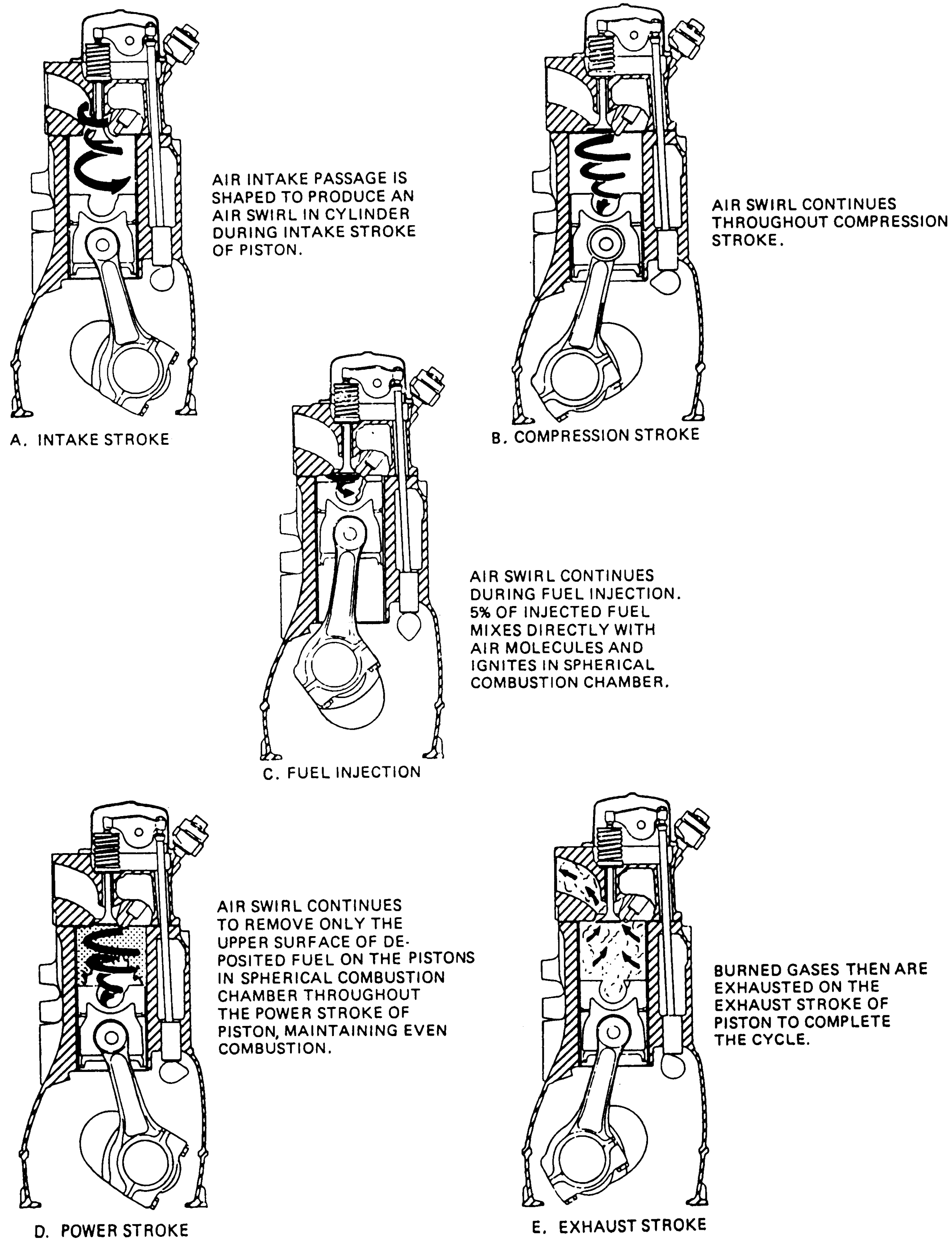


Figure 1-11.—Multifuel engine.



AIR INTAKE PASSAGE IS SHAPED TO PRODUCE AN AIR SWIRL IN CYLINDER DURING INTAKE STROKE OF PISTON.

A. INTAKE STROKE

AIR SWIRL CONTINUES THROUGHOUT COMPRESSION STROKE.

B. COMPRESSION STROKE

AIR SWIRL CONTINUES DURING FUEL INJECTION. 5% OF INJECTED FUEL MIXES DIRECTLY WITH AIR MOLECULES AND IGNITES IN SPHERICAL COMBUSTION CHAMBER.

C. FUEL INJECTION

AIR SWIRL CONTINUES TO REMOVE ONLY THE UPPER SURFACE OF DEPOSITED FUEL ON THE PISTONS IN SPHERICAL COMBUSTION CHAMBER THROUGHOUT THE POWER STROKE OF PISTON, MAINTAINING EVEN COMBUSTION.

D. POWER STROKE

BURNED GASES THEN ARE EXHAUSTED ON THE EXHAUST STROKE OF PISTON TO COMPLETE THE CYCLE.

E. EXHAUST STROKE

Figure 1-12.-Spherical chamber.

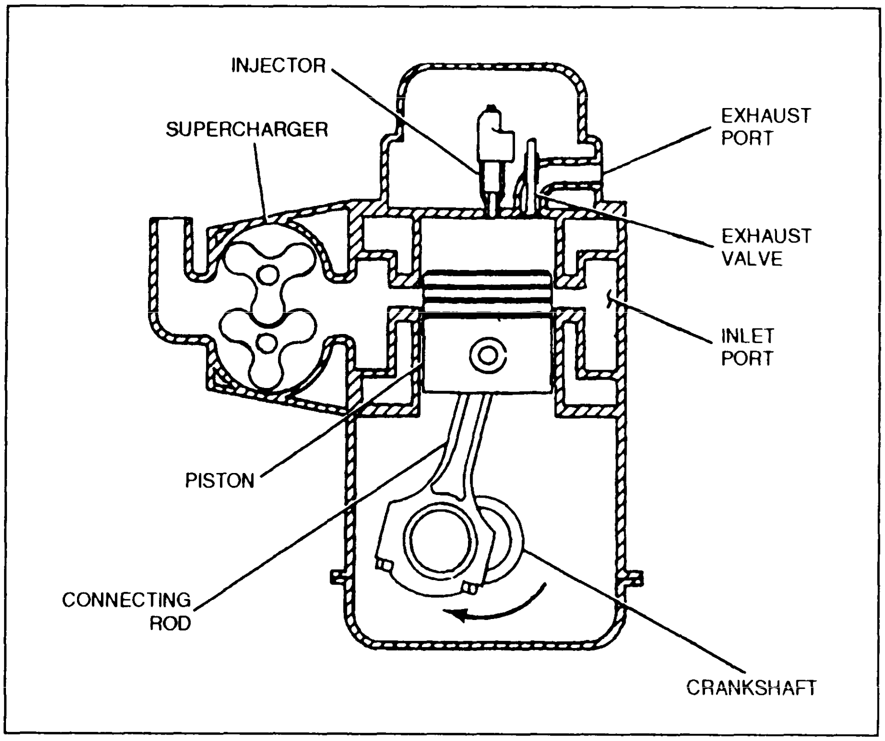


Figure 1-13.—Two-stroke cycle diesel engine.

Two-Stroke Cycle Diesel Engine

A two-troke diesel engine (fig. 1-13) shares the same operating principles as other internal combustion engines. It has all of the advantages that other diesel engines have over gasoline engines.

A two-stroke diesel engine does not produce as much power as a four-stroke diesel engine; however, it runs smoother than the four-stroke diesel. This is because it generates a power stroke each time the piston moves downward; that is, once for each crankshaft revolution. The two-stroke diesel engine has a less complicated valve train because it does not use intake valves. Instead, it requires a supercharger to force air into the cylinder and force exhaust gases out, because the piston cannot do this naturally as in four-stroke engines.

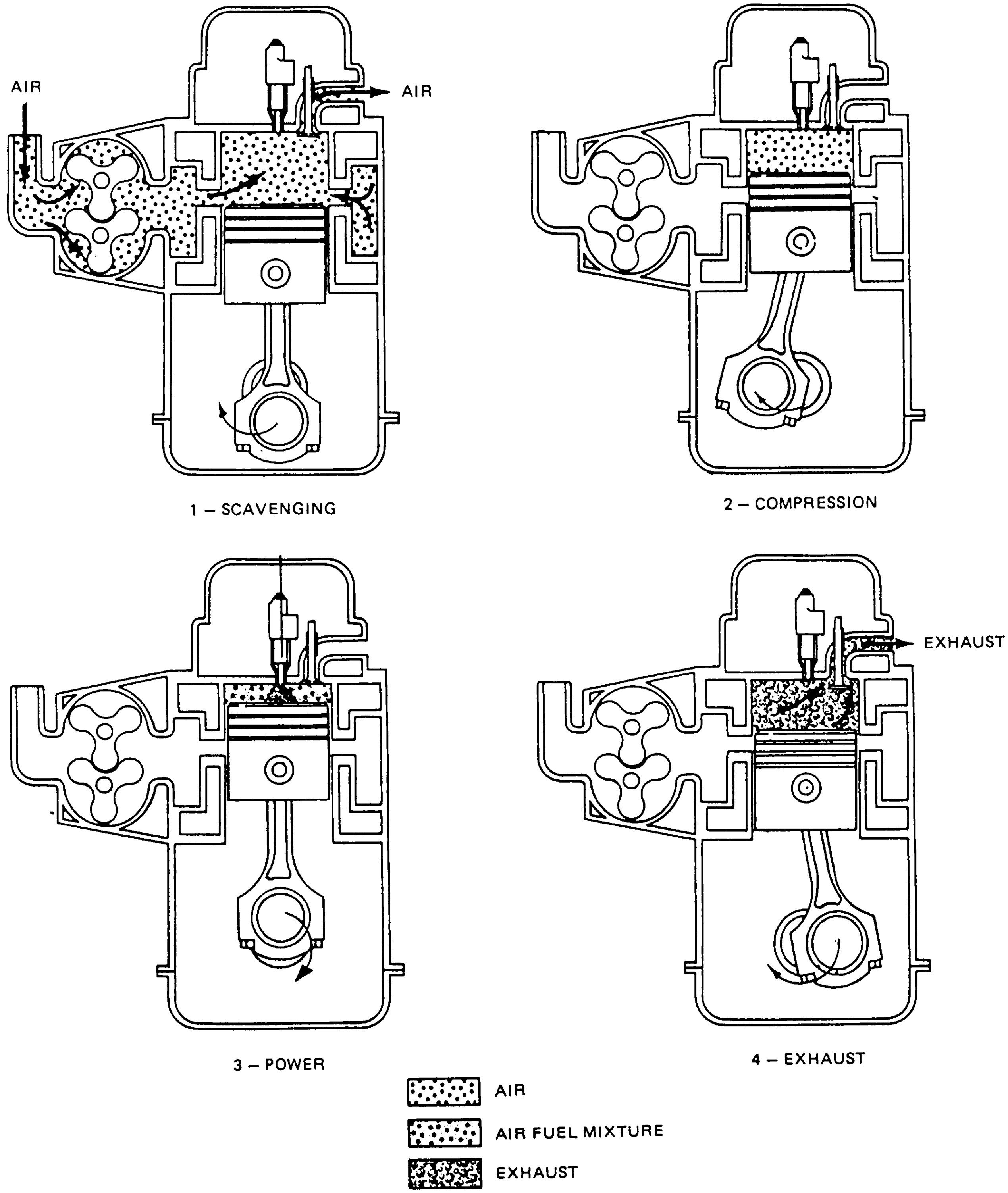
The two-stroke diesel takes in air and discharges exhaust through a system called scavenging. Scavenging begins with the piston at bottom dead center. At this point, the intake ports are uncovered in the cylinder wall and the exhaust valve is open. The supercharger forces air into the cylinder, and, as the air is forced in, the burned gases from the previous operating cycle are forced out (fig. 1-14).

COMPRESSION STROKE.— As the piston moves towards top dead center, it covers the intake ports. The exhaust valves close at this point and seals the upper cylinder. As the piston continues upward, the air in the cylinder is tightly compressed (fig. 1-14). As in the four-stroke cycle diesel, a tremendous amount of heat is generated by the compression.

POWER STROKE.— As the piston reaches top dead center, the compression stroke ends. Fuel is injected at this point and the intense heat of the compression causes the fuel to ignite. The burning fuel pushes the piston down, giving power to the crankshaft. The power stroke ends when the piston gets down to the point where the intake ports are uncovered. At about this point, the exhaust valve opens and scavenging begins again, as shown in figure 1-14.

Valve Train

The operation of the valves in a timed sequence is critical. If the exhaust valve opened in the middle of the intake stroke, the piston would draw burnt gases into the combustion chamber with a fresh mixture of fuel and air. As the piston continued to the power stroke, there would be nothing in the combustion chamber that would


AIR
AIR
EXHAUST
AIR
AIR FUEL MIXTURE
EXHAUST

1 – SCAVENGING

2 – COMPRESSION

3 – POWER

4 – EXHAUST

Figure 1-14.—Two-stroke diesel cycle.

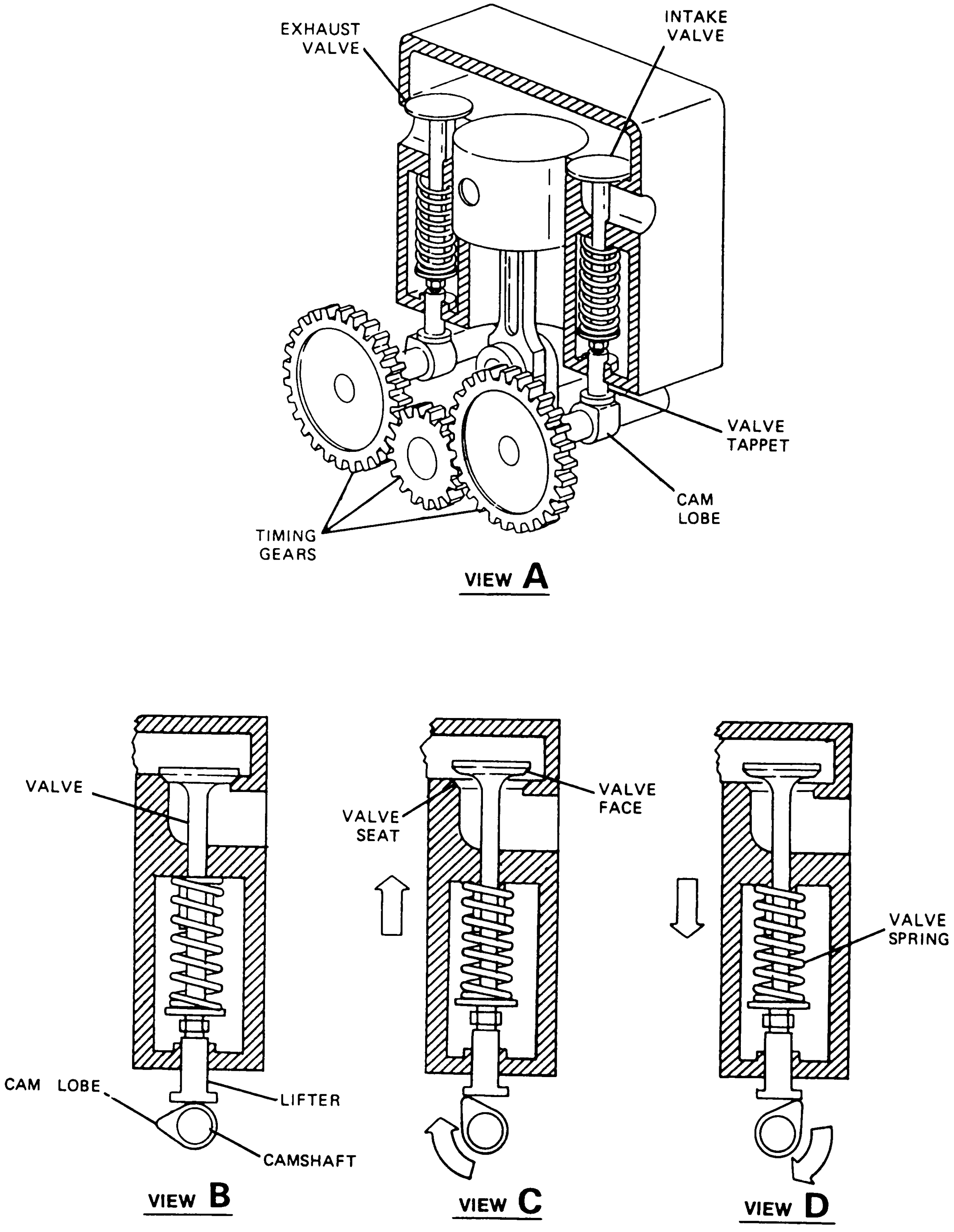

EXHAUST VALVE
INTAKE VALVE
VALVE TAPPET
CAM LOBE
TIMING GEARS
VIEW A
VALVE
CAM LOBE
LIFTER
CAMSHAFT
VIEW B
VALVE SEAT
VALVE FACE
VIEW C
VALVE SPRING
VIEW D

Figure 1-15.—Valve train operation.

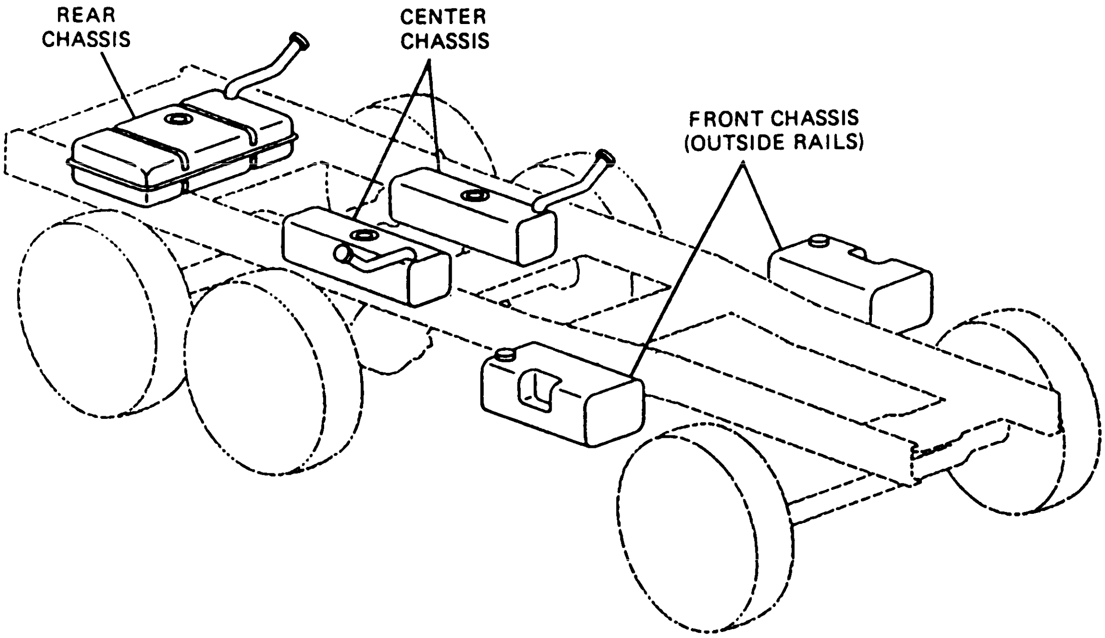

REAR CHASSIS
CENTER CHASSIS
FRONT CHASSIS (OUTSIDE RAILS)

Figure 1-16.-Common fuel tank locations.

bum. The engine is fitted with a valve train to operate the valves, as shown in figure 1-15.

The camshaft is made to rotate with the crankshaft through the timing gears. The cam lobe is the raised portion on the camshaft that contacts the bottom of the lifter. As the cam rotates, the lobe pushes up on the lifter. The cam lobe pushes the valve open against the pressure of a spring. As the cam lobe rotates away from the lifter, the valve spring pulls the valve closed. The proper positioning of the cam lobes on the camshaft establishes a sequence for the intake and exhaust valves.

FUEL SYSTEMS

The function of the fuel system is to ensure a quantity of clean fuel is delivered to the fuel intake of an engine. The system must provide both safe fuel storage and transfer.

FUEL TANKS

Fuel tanks store fuel in liquid form. The tank may be located in any part of a vehicle that is protected from flying debris, shielded from collisions, and not likely to bottom out (fig. 1-16). Most wheeled vehicles use removable fuel tanks.

Most fuel tanks are made of thin sheet metal coated with a lead-tin alloy to prevent corrosion. Fiber glass and a variety of molded plastics are also popular as corrosion-resistant materials.

The walls of fuel tanks are manufactured with ridges to give them strength and internal baffles that increase internal strength and prevent the fuel from sloshing (fig. 1-17). The filler pipe offers a convenient opening to fill the tank and prevent fuel from being spilled onto the

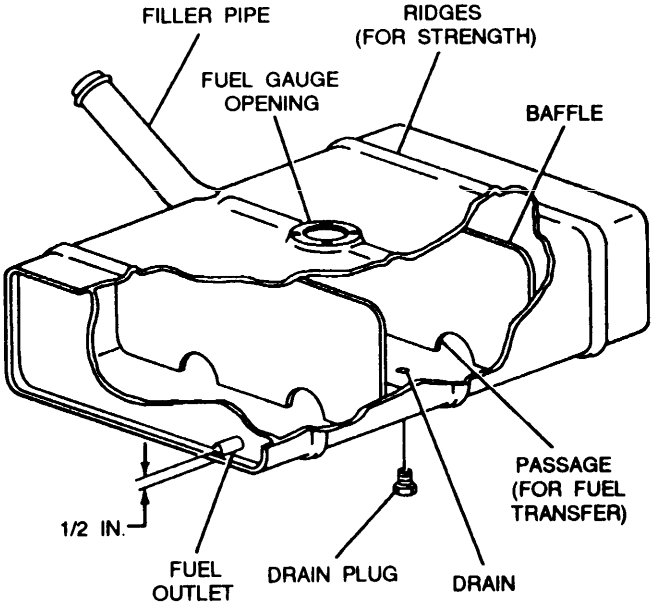

FILLER PIPE
RIDGES (FOR STRENGTH)
FUEL GAUGE OPENING
BAFFLE
PASSAGE (FOR FUEL TRANSFER)
1/2 IN.
FUEL OUTLET
DRAIN PLUG
DRAIN

Figure 1-17.-Fuel tank construction.

passenger, engine, or cargo compartments. The fuel outlet pipe is located inside the tank and its opening is about one-half inch above the bottom. This location allows sediment to fall to the bottom of the fuel tank without being drawn into the fuel system. Most fuel tanks have a position on top to install a fuel gauge sending unit. This is usually a flanged hole. A threaded drain plug is normally located at the bottom of the tank and is used for draining and cleaning of the tank.

Gasoline Fuel

Gasoline, a by-product of petroleum, contains carbon and hydrogen. This factor allows the fuel to burn freely and to create extensive heat energy. Two types of gasoline are used: leaded and unleaded. Leaded gasoline has a higher octane rating than unleaded gasoline and is more effective as a valve and valve seat lubricant; however, leaded gasoline has almost been discontinued, because engines that use it emit a great amount of harmful hydrocarbons that pollute the atmosphere. Engines that use unleaded gasoline emit fewer hydrocarbons, have fewer combustion chamber deposits, and provide a longer life for spark plugs, exhaust systems, and carburetors; however, unleaded gasoline emits about the same amount of carbon monoxide and nitrogen oxide as leaded gasoline.

NOTE: The octane number in gasoline is a measure of its ability to burn evenly and resist spontaneous combustion. A knock in a gasoline engine is caused by gases burning too rapidly.

Catalytic Converter

A catalytic converter is positioned in the exhaust system, usually between the engine and the muffler, to control the emission of carbon monoxide and hydrocarbons produced from burning gasoline. As the engine exhaust passes through the converter, carbon monoxide and hydrocarbons are oxidized (combined with oxygen), changing them to carbon dioxide and water. This oxidation causes the outer shell of the converter to operate consistently at temperatures that are several hundred degrees higher than the rest of the exhaust system. The outer shell of the catalytic converter is normally made of stainless steel to cope with the high operating temperatures.

A chemical catalyst is an element or chemical compound that increases the reaction between two other chemicals without reacting with them. In this case, the catalyst in the catalytic converter increases the reaction between oxygen and the harmful carbon monoxide and hydrocarbons to produce harmless carbon dioxide and water emissions.

Platinum and palladium are precious metals often used as catalysts in catalytic converters. Small amounts of the catalysts are used to coat the surfaces of the material in the converter. Two common types of converters are shown in figure 1-18.

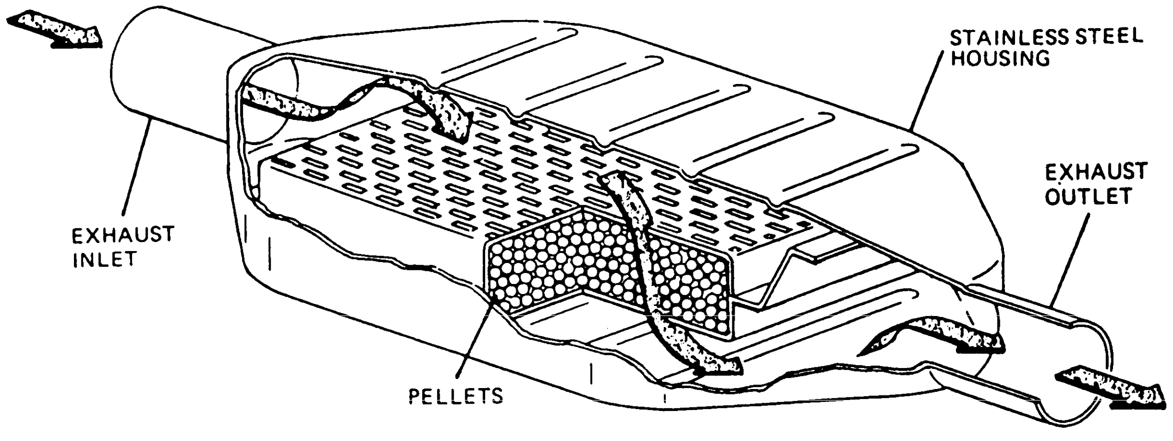
NOTE: The use of leaded gasoline is destructive to a catalytic converter. The lead in the exhaust can coat the catalyst as it passes through the converter, and this coating can completely halt catalytic converter operations.

Diesel Fuel

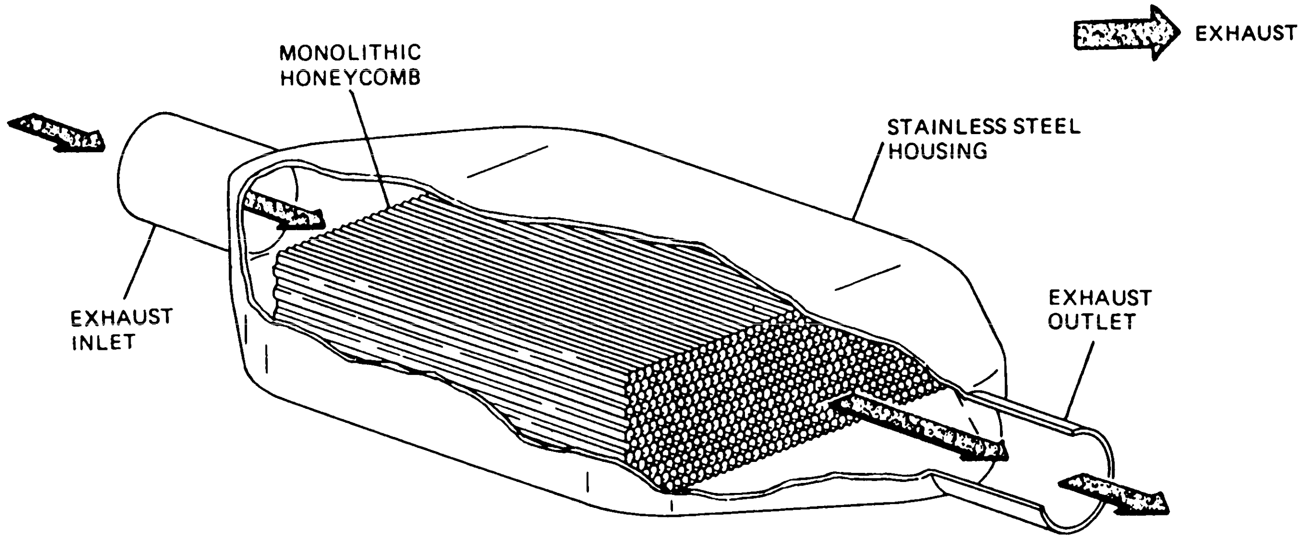
Diesel fuel comes from the residue of the crude oil after the more volatile fuels, such as gasoline and kerosene, are removed during the petroleum refining process. As with gasoline, the efficiency of a diesel fuel varies with the type of engine. The refining and blending process can produce a suitable diesel fuel for almost any engine operating conditions. Using a contaminated fuel or an improper grade of fuel can cause hard starting, incomplete combustion, a smokey exhaust, or cause an engine to knock.

Cleanliness of diesel fuel is important because fuel containing more than a trace of foreign substances can cause fuel pump and injector problems to develop. Diesel fuels can hold dirt particles in suspension longer than gasoline because it is heavier and more viscous. In refining, not all foreign materials can be removed, and harmful matter, such as dirt and water, can get into the fuel during the handling process, Water can rust an injection system and cause it to fail. Dirt clogs injectors and spray nozzles and can cause an engine to misfire or stop altogether. To be safe, remember to take precautions when refueling and try to prevent foreign matter from entering the fuel tank.

High-cetane diesel fuels allow diesel engines to be started at low temperatures, provide fast warmups without misfiring or producing white smoke, reduce the formation of carbon deposits, and eliminate diesel knock. However, a too high cetane number can lead to incomplete combustion and exhaust smoke if the delay is too short to allow for proper mixing of fuel and air. Most diesel fuels range from 33 to 64 in cetane number, with 40 the minimum for military grades DF-1 and DF-2.


STAINLESS STEEL HOUSING
EXHAUST OUTLET
EXHAUST INLET
PELLETS

A. PELLET TYPE


EXHAUST
MONOLITHIC HONEYCOMB
STAINLESS STEEL HOUSING
EXHAUST INLET
EXHAUST OUTLET

B. MONOLITHIC TYPE

Figure 1-18.-Catalytic converter.

NOTE: The cetane number is a measure of the ability of a diesel fuel to provide fast spontaneous combustion with short ignition delay. A knock in a diesel engine is caused by the fuel igniting too slowly.

Jet Fuel

You may be deployed to some sites at which diesel fuel is not available and JET FUEL has to be used. The three major types of jet fuel used by the military are JP-4, JET-A1, and JP-5. **DO NOT USE JP-4 IN ANY DIESEL ENGINE.** The maintenance supervisor approves the use of JET-A1 and JP-5 and directs the amount of engine oil that must be added to the jet fuel. This must be done to improve the lubricating qualities that prevent the injector pump and injectors from seizing.

FUEL FILTERS

Fuel filters trap foreign material that may be present in the fuel and prevent it from entering the carburetor or sensitive fuel injection components.

Gasoline Fuel Filter

On a gasoline engine system there is at least one fuel filter used in the fuel system and it can be located in any accessible place along the fuel delivery line. Filters also can be located inside fuel tanks, carburetors, and fuel pumps.

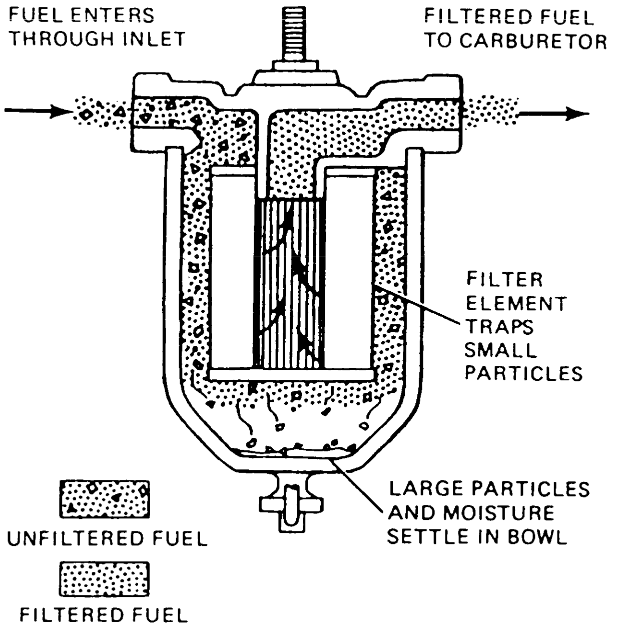

FUEL ENTERS THROUGH INLET
FILTERED FUEL TO CARBURETOR
FILTER ELEMENT TRAPS SMALL PARTICLES
LARGE PARTICLES AND MOISTURE SETTLE IN BOWL
UNFILTERED FUEL
FILTERED FUEL

Figure 1-19.—Fuel filter operation.

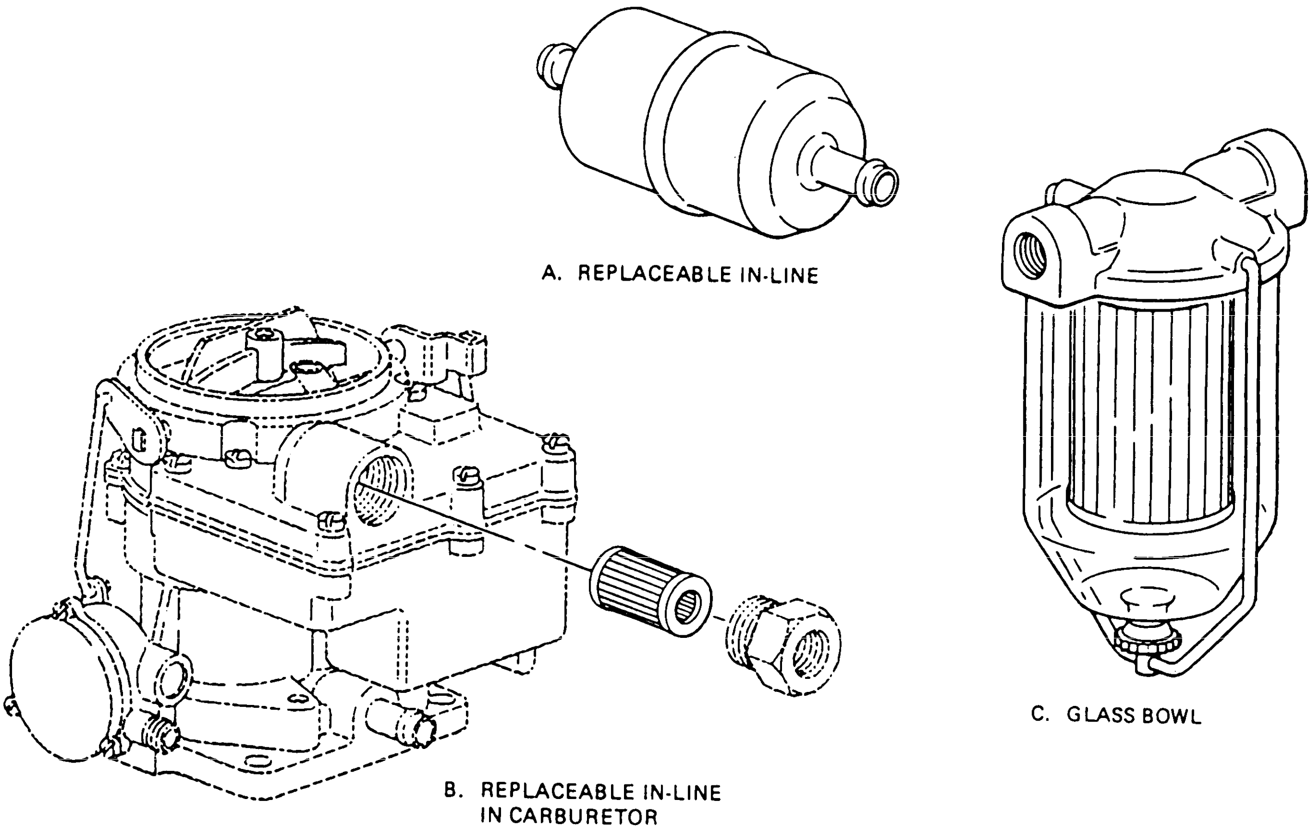
The fuel filter operates by passing fuel through a porous material that blocks particles large enough to cause a problem in the system. Some filters also act as sediment bowls; water and larger particles of foreign matter settle to the bottom where they can be drained off (fig. 1-19).

Figure 1-20 shows the three types of fuel filters in common use. They are the replaceable in-line filter (view A), the in-line filter element (view B), and the glass bowl (view C).

Filter elements are made from ceramic, treated paper, sintered bronze, or metal screen, as shown in figure 1-21. A filter element that differs from the others is a series of closely spaced laminated disks. As the gasoline proses between the disks, foreign matter is blocked out.

Diesel Fuel Filters

Diesel fuel filters are called full-flow filters, because all the fuel must pass through them before reaching the injection pumps. They are very important because diesel fuels are more viscous than gasoline and


A. REPLACEABLE IN-LINE

B. REPLACEABLE IN-LINE IN CARBURETOR

C. GLASS BOWL

Figure 1-20.—Fuel filter configurations.

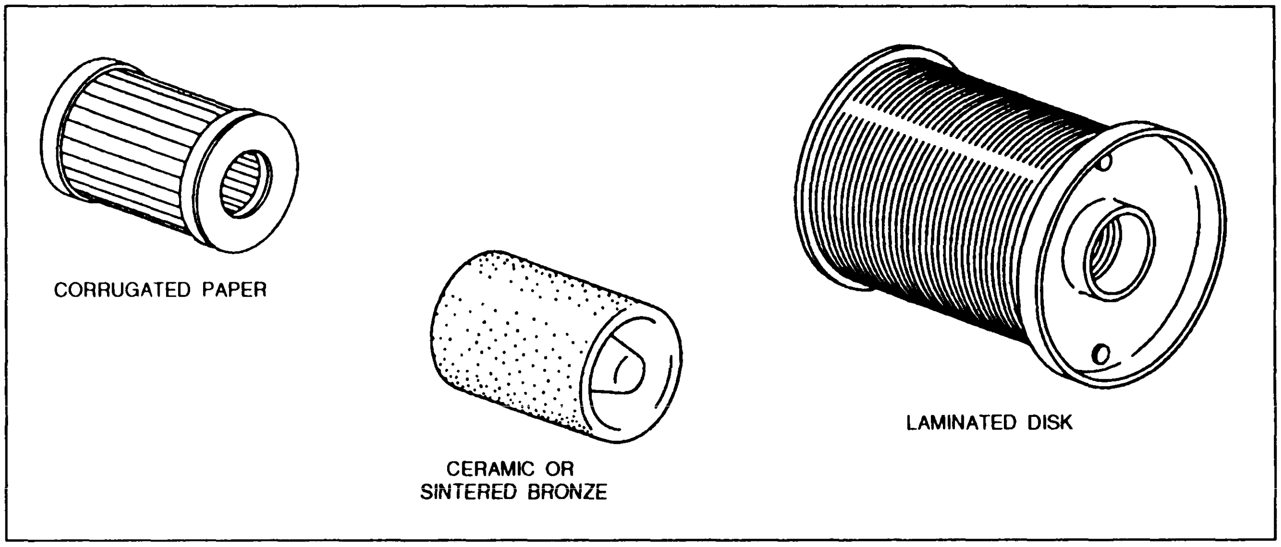


Figure 1-21.—Fuel filter elements.

contain more gum and abrasive particles that can cause premature wear of injection equipment. Some diesel fuel filters have an air valve to release any air that accumulates in the filter during operation.

Most diesel engine designs include two filters in the fuel supply system: a primary filter and a secondary filter.

PRIMARY FILTER.— In most designs, the primary filter is located between the fuel tank and the fuel supply pump. A primary falter contains a coarse filter material that removes the larger foreign matter. They are metal filters and only allow fine particles to pass through them (fig. 1-22). Solid materials larger than 0.005 inch remain outside the metal disks, while the larger foreign matter and most of the water settle to the bottom of the bowl. This matter can be removed through a drain plug. A ball relief valve in the filter cover enables the fuel to bypass the filter element if the disks become clogged. Most types of heavy equipment have a fuel pressure gauge that indicates when the filters are dirty.

NOTE: A good practice is to drain about one fourth of a pint of fuel out of the filter into a container or onto a rag during the prestart operations. This practice allows you to drain out any foreign matter that has settled to the bottom of the filter.

SECONDARY FILTER.— The secondary falter is usually located between the fuel supply pump and the fuel injection pump. It contains a fine filter that removes even the most minute traces of foreign matter from the

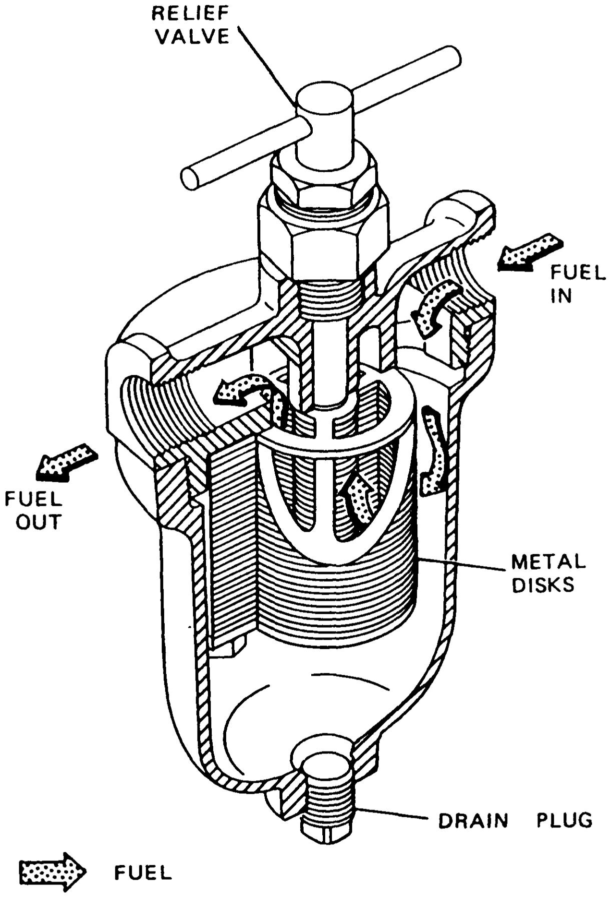


Figure 1-22.-Primary fuel filter.

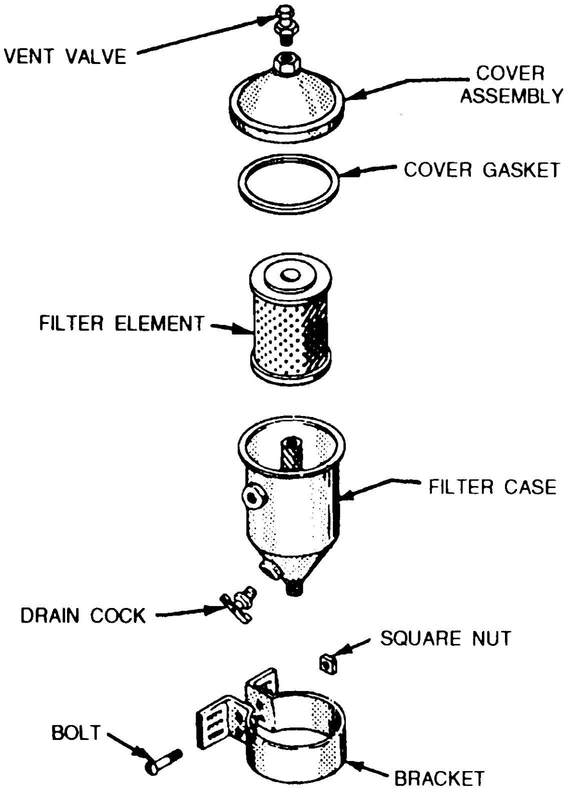

VENT VALVE
COVER ASSEMBLY
COVER GASKET
FILTER ELEMENT
FILTER CASE
DRAIN COCK
SQUARE NUT
BOLT
BRACKET

Figure 1-23.-Secondary fuel filter.

fuel. Secondary filters (fig. 1-23) are fabric filters that have greater filtering qualities than primary filters. They arc used principally as the primary filter to protect the fuel injection pump.

GASOLINE FUEL SYSTEM

The three basic parts of a gasoline fuel system are the fuel tank, fuel pump, and carburetor. Fuel is supplied from the fuel tank to the carburetor by either a gravity-feed system or a force-feed system. The gravity-feed system has the fuel tank placed above the carburetor (fig. 1-24). Afloat attached to a valve allows fuel to enter the carburetor at the same rate at which the engine is consuming it. This system maintains a uniform level in the carburetor regardless of the amount of fuel in the tank. The force-feed system (fig. 1-24) is where the fuel tank is located below the carburetor and a fuel pump is required.

Fuel Pump

The fuel pump draws the gasoline through a fuel line from the tank and forces it to the float chamber of the carburetor where it is stopped. Several types of fuel pumps are used; however, the most common type is the mechanical nonpositive fuel pump (fig. 1-25).

Carburetor

The carburetor is basically an air tube that operates by a differential in air pressure. It has an hourglass-shaped tube called a **throat** and the most constricted part

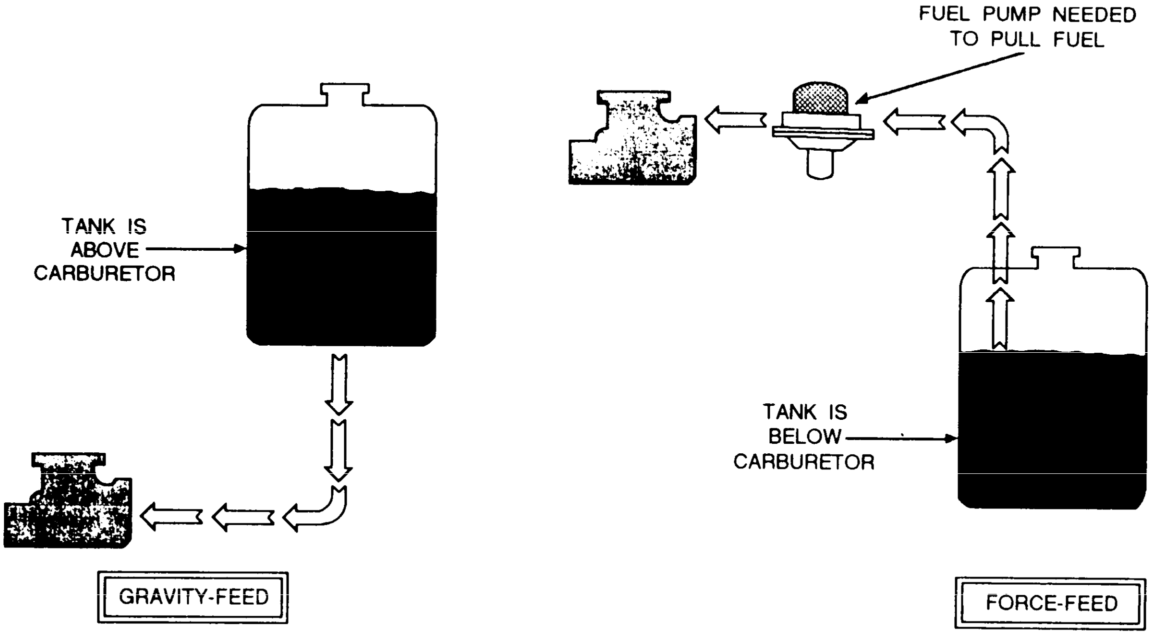
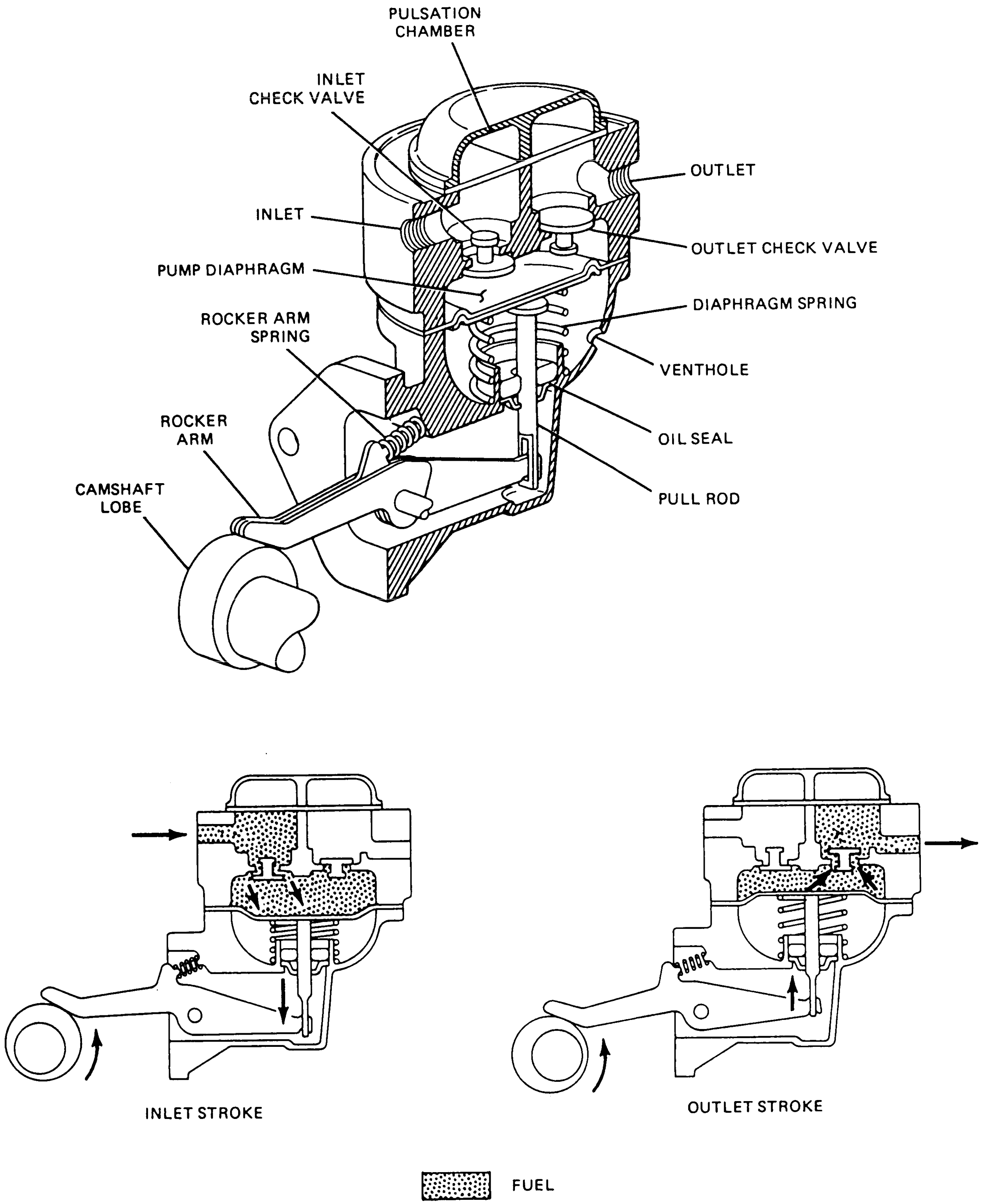

TANK IS ABOVE CARBURETOR
GRAVITY-FEED
FUEL PUMP NEEDED TO PULL FUEL
TANK IS BELOW CARBURETOR
FORCE-FEED

Figure 1-24.-Fuel systems.


PULSATION CHAMBER
INLET CHECK VALVE
OUTLET
INLET
OUTLET CHECK VALVE
PUMP DIAPHRAGM
DIAPHRAGM SPRING
ROCKER ARM SPRING
VENTHOLE
ROCKER ARM
OIL SEAL
CAMSHAFT LOBE
PULL ROD
FUEL

INLET STROKE

OUTLET STROKE

Figure 1-25.-Mechanical nonpositive pump.

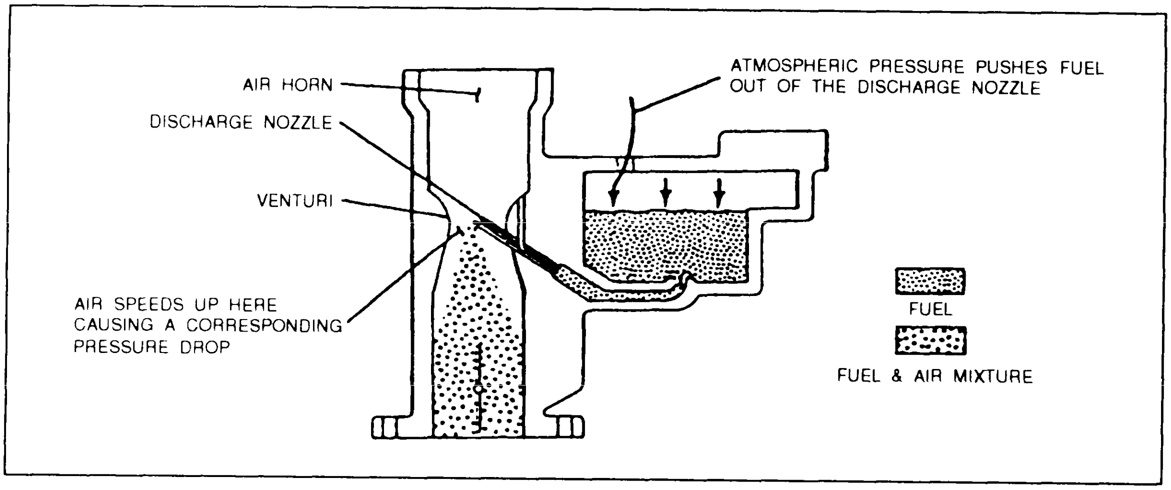

AIR HORN
DISCHARGE NOZZLE
VENTURI
AIR SPEEDS UP HERE CAUSING A CORRESPONDING PRESSURE DROP
ATMOSPHERIC PRESSURE PUSHES FUEL OUT OF THE DISCHARGE NOZZLE
FUEL
FUEL & AIR MIXTURE

Figure 1-26.—Venturi effect.

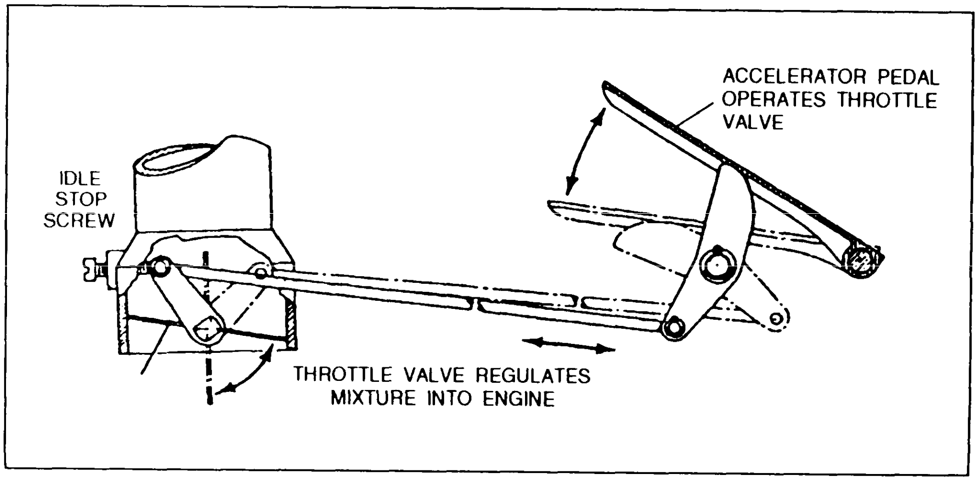

IDLE STOP SCREW
ACCELERATOR PEDAL OPERATES THROTTLE VALVE
THROTTLE VALVE REGULATES MIXTURE INTO ENGINE

Figure 1-27.—Throttle valve.

of the throat is called the venturi (fig. 1-26). A tube called a discharge nozzle is positioned in the venturi and is connected to a reservoir of gasoline called the float bowl.

The downward intake stroke of the piston creates a partial vacuum in the carburetor throat that allows low-pressure air to rush by the fuel nozzle. This forces small drops of fuel to be mixed with the air. Then the fuel and air mixture must pass the throttle valve which is controlled by the operator (fig. 1-27). The throttle valve opens or closes to allow the correct volume of the fuel and air mixture into the engine. The choke valve (fig. 1-28) also controls the supply of fuel to the engine. When you start the engine in cold weather, the choke valve can be partly closed, forming a restriction that causes more fuel and less air to be drawn into the combustion chamber. This results in a richer air to fuel

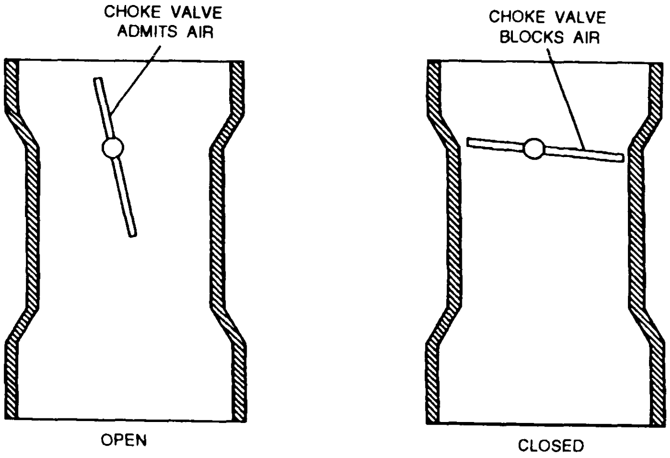

CHOKE VALVE ADMITS AIR
CHOKE VALVE BLOCKS AIR
OPEN
CLOSED

Figure 1-28.-Choke valve operation.

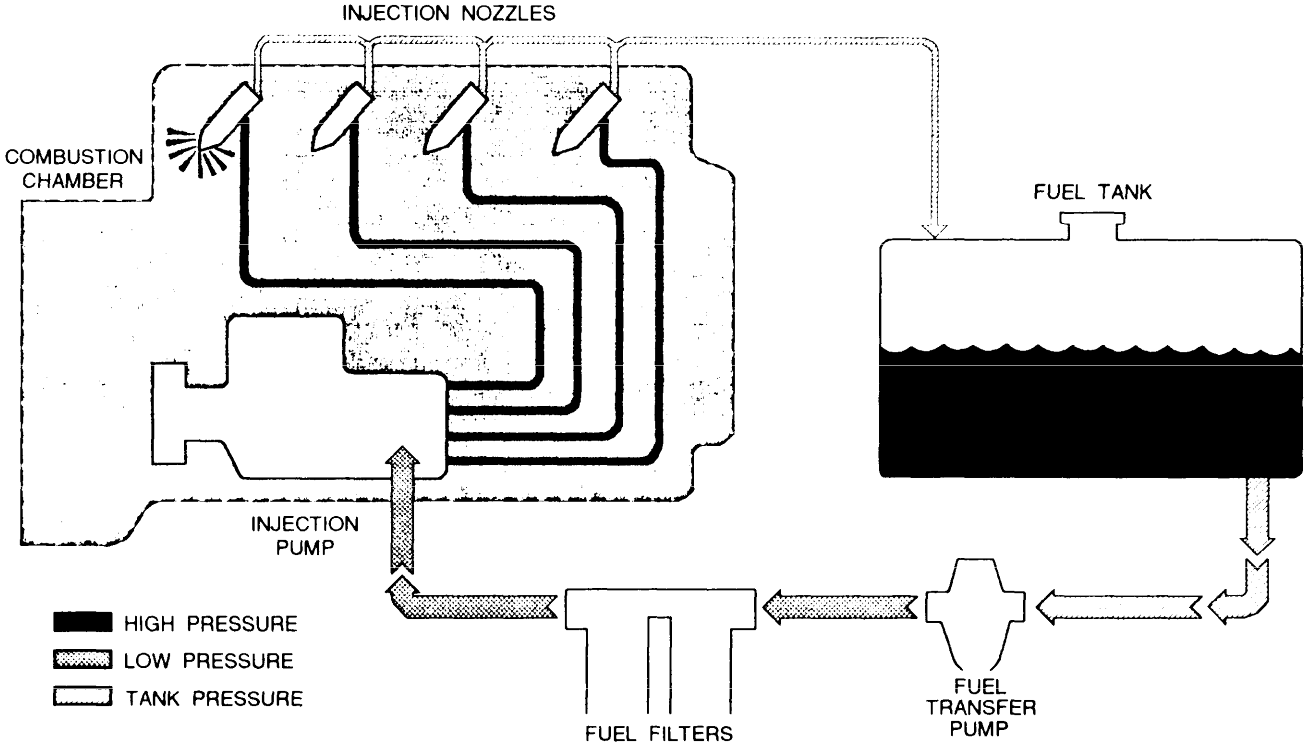


Figure 1-29.—Diesel fuel system.

mixture in the cylinders for the harder job of starting at low temperature.

DIESEL FUEL SYSTEM

The primary job of the diesel fuel system is to inject a precise amount of atomized and pressurized fuel into each engine cylinder at the precise time. The major parts of the diesel system are the fuel tank, fuel transfer pump, fuel filters, injection pump, and injection nozzles (fig. 1-29).

Fuel Transfer Pump

The fuel transfer pump is normally used on modern high-speed diesel engines. It can be driven by either engine or battery voltage. The fuel transfer pump can be located on the outside of the fuel tank in the supply line, submerged within the fuel tank, or mounted on the backside of the injection pump. The fuel pump pushes or draws the fuel through the filters where the fuel is cleaned.

Injection Pump

Several types of injection pumps are used on diesel engines. Each has its own unique operating principles. The primary function of the injection pump is to supply high-pressure fuel for injection.

Injection Nozzles

A wide variety of injector nozzles are in use today. All are designed to perform the same basic function which is to spray the fuel in atomized form into the combustion chamber of each cylinder.

Cold Weather Starting Aids

Diesel fuel evaporates much slower than gasoline and requires more heat to cause combustion in the cylinders of the engine. For this reason, preheater and starting aids, called glow plugs, are installed on equipment equipped with diesel engines.

PREHEATERS.— Preheaters are normally installed in the intake manifold; however, in a two-stroke cycle engine, they are placed in the air passages surrounding the cylinders. The preheater burns a small quantity of diesel fuel in the air before the air is drawn into the cylinders. This burning process is accomplished by the use of either a glow plug or an ignition coil that produces a spark to ignite a fine spray of diesel fuel. The resulting heat warms the remaining air before it is drawn into the cylinders.

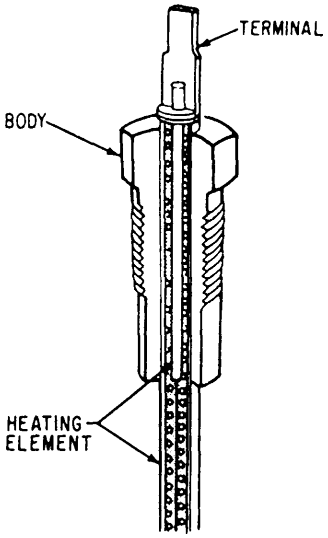


Figure 1-30.-Glow plug.

GLOW PLUGS.— Glow plugs (fig. 1-30) and the injection nozzle are installed in the precombustion chamber of the cylinder head. The glow plug is turned on when you turn on the ignition switch. On some equipment a light on the dashboard signals that the glow plug is cycling which signals you to wait between 15 to 30 seconds before cranking the engine. The heat, created by electrical resistance in the glow plug, heats the fuel and air mixture. The heat generated by the glow plug and the heat generated by compression allow the fuel to ignite.

AIR INDUCTION SYSTEMS

The function of an air intake system is to supply the correct amount of air needed to increase the combustion and the efficiency of an engine. On a diesel engine, the air intake system cleans the intake air, silences the intake noise, furnishes air for supercharging, and supplies scavenged air in two-stroke engines.

The three major components of the air induction system are blowers, turbochargers, and superchargers. They may be of the centrifugal or rotary type, or they may be gear-driven directly from the engine, belt or chain-driven, or driven by the flow of exhaust gases from the engine.

BLOWERS

The scavenging process, used in the two-stroke cycle diesel engine, is simply a charge of air forced into the cylinder by the blower. As this charge of air is forced into the cylinder, all the burnt gases are swept out through the exhaust valve ports. This air also helps cool the internal engine parts, particularly the exhaust valves.

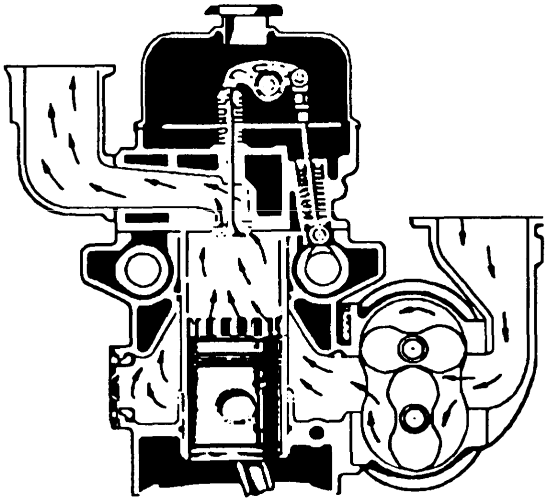


Figure 1-31.—Blower air intake system.

The blower shown in figure 1-31 provides the forced-air induction for the scavenging process. Two rotors are closely fitted in a housing that is bolted to the engine. The rotor lobes provide continuous and uniform displacement of air as the rotors revolve. Blower rotors either have two lobes or three lobes, depending on the type.

TURBOCHARGERS

The four-stroke cycle engine uses two methods of air induction: naturally aspirated and turbo charged. The naturally aspirated system depends on atmospheric pressure to keep a constant supply of air in the intake manifold. The turbocharger is designed to force air into the cylinder and aid in scavenging the exhaust gases. The turbocharger differs from the blower in that the turbocharger uses the energy of exhaust gases to drive a turbine wheel (fig. 1-32).

The hot exhaust gases from the engine go through the exhaust inlet, across the turbine wheel, and out the exhaust outlet. The force of the exhaust turns the turbine wheel and shaft. This action rotates the compressor wheel (impeller) that is attached to the opposite end of the turbine shaft. As the impeller rotates, it draws air into the housing. The air is then compressed and forced into the intake manifold.

SUPERCHARGERS

Superchargers are engine-driven air pumps that force the air and fuel mixture into the engine. They are made in three basic configurations: centrifugal, Roots, and vane.

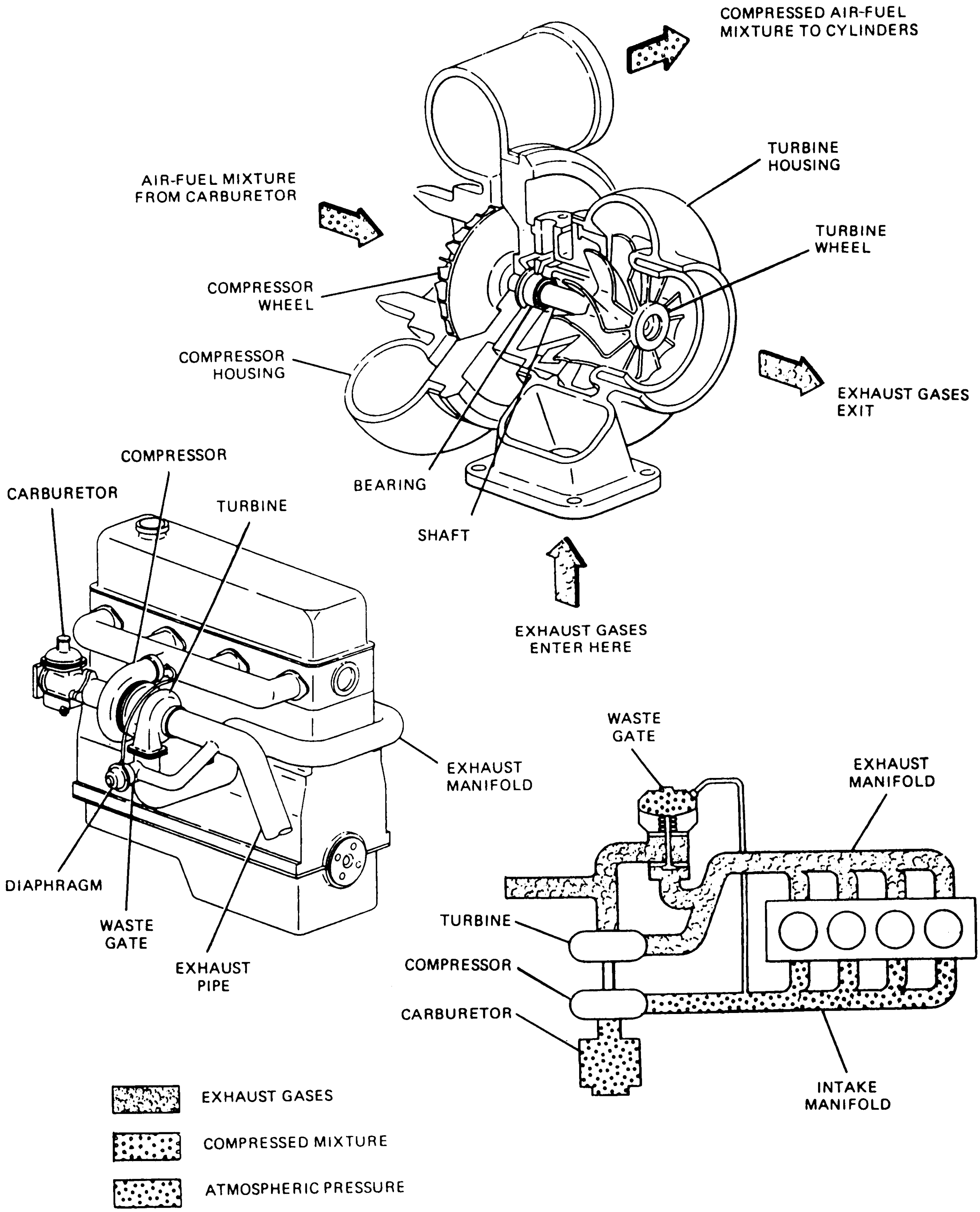
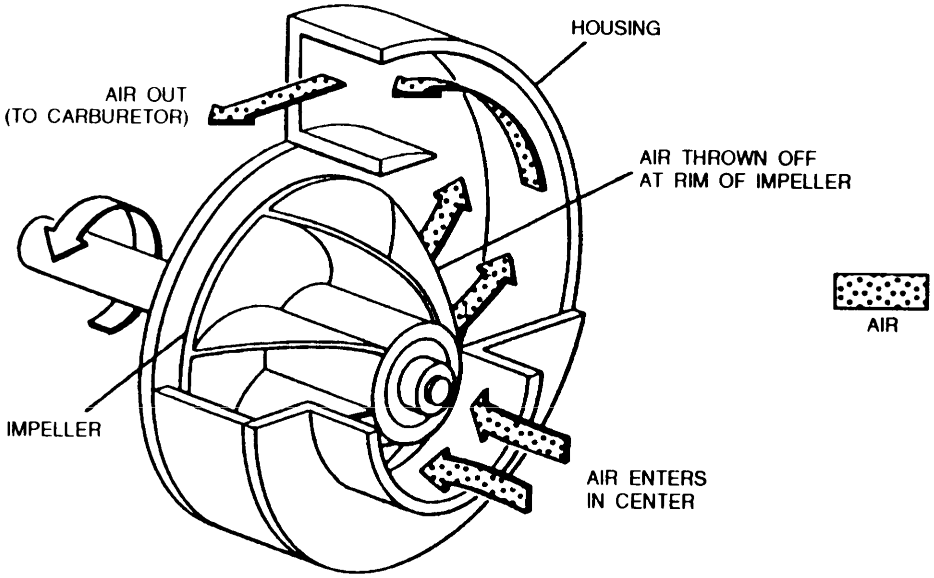
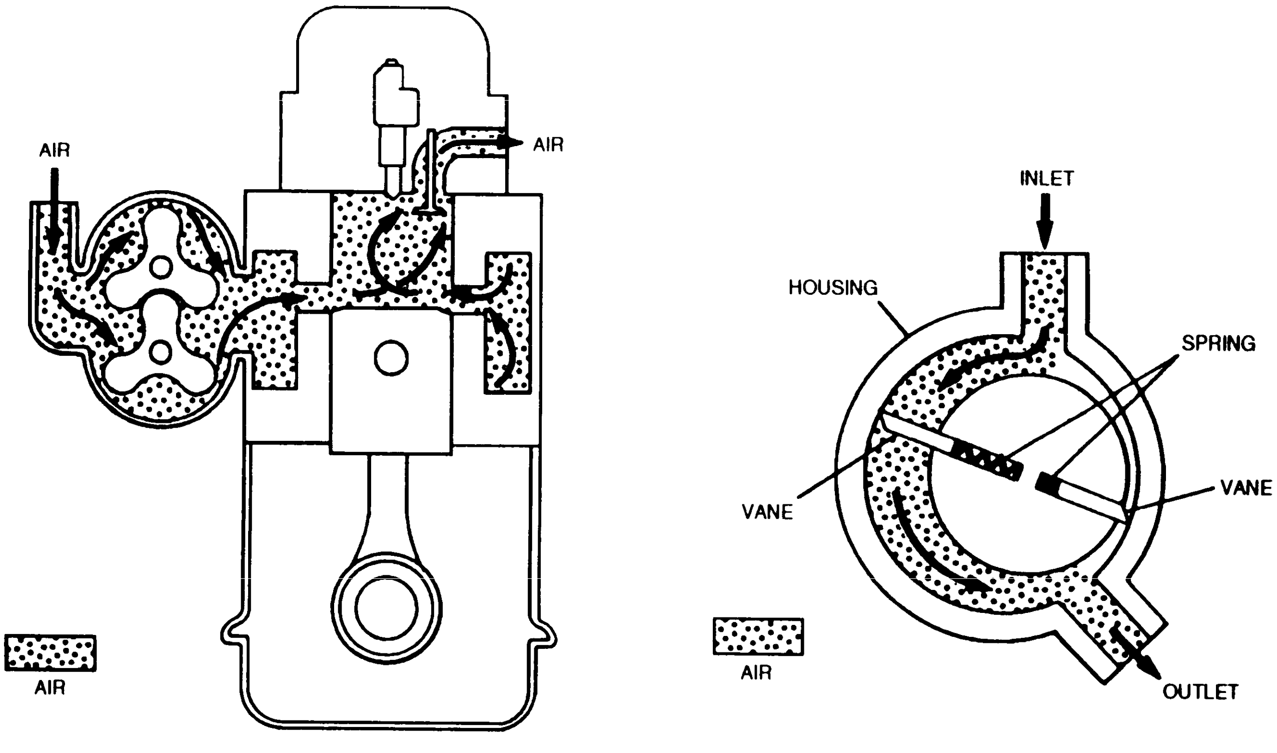

COMPRESSED AIR-FUEL MIXTURE TO CYLINDERS
TURBINE HOUSING
AIR-FUEL MIXTURE FROM CARBURETOR
TURBINE WHEEL
COMPRESSOR WHEEL
COMPRESSOR HOUSING
EXHAUST GASES EXIT
COMPRESSOR
CARBURETOR
BEARING
TURBINE
SHAFT
EXHAUST GASES ENTER HERE
WASTE GATE
EXHAUST MANIFOLD
EXHAUST MANIFOLD
DIAPHRAGM
WASTE GATE
TURBINE
EXHAUST PIPE
COMPRESSOR
CARBURETOR
INTAKE MANIFOLD
EXHAUST GASES
COMPRESSED MIXTURE
ATMOSPHERIC PRESSURE

Figure 1-32.-Turbocharger.


HOUSING
AIR OUT (TO CARBURETOR)
AIR THROWN OFF AT RIM OF IMPELLER
AIR
IMPELLER
AIR ENTERS IN CENTER

A. CENTRIFUGAL SUPERCHARGER


AIR
AIR
AIR
INLET
HOUSING
SPRING
VANE
VANE
AIR
OUTLET

B. ROOTS SUPERCHARGER

C. VANE SUPERCHARGER

Figure 1-33.-Superchargers.

Centrifugal Supercharger

The centrifugal supercharger (fig. 1-33, view A) has an impeller equipped with curved vanes. As the impeller is driven by the engine, it draws air into its center and throws it off at its rim. The air then is pushed along the inside of the circular housing. The diameter of the housing gradually increases to the outlet where the air is pushed out to the engine intake system.

Roots Supercharger

The Roots supercharger (fig. 1-33, view B) is a positive displacement type of supercharger that consists of two rotors inside a housing. As the rotors are driven by the engine, air is trapped between them and the housing. The air is then carried to the outlet where it is discharged. Because of the extremely narrow clearance between the rotors and the housing, this supercharger is very sensitive to dirt.

Vane Supercharger

The vane supercharger (fig. 1-33, view C) is a positive displacement supercharger that has a rotor that revolves in a body, the bore of which is eccentric to the rotor. Two sliding vanes are placed 180 degrees apart in slots in the rotor and are pressed against the body bore by springs in the slots. When the shaft is rotated, the vanes pick up air at the inlet port and carry it around the body to the outlet side where the air is discharged to the intake system of the engine.

AIR CLEANERS

Clean air is essential to the performance and life of an engine. The air cleaner must remove fine materials, such as sand, dust, or lint, from the air before it enters the intake system. The air cleaner normally has a reservoir large enough to hold material taken out of the air; therefore, operation over a reasonable time is possible before cleaning and servicing are necessary.

NOTE: A buildup of dust and dirt in the air cleaner passages will eventually choke off the air supply, causing poor combustion.

Multiple air cleaners are sometimes used in locations where engines are operated under extremely dusty air conditions or when two small air cleaners must be used in place of a single large cleaner.

The most common type of air cleaners are the following: pre-cleaners, dry air cleaners, dry element air cleaners, and oil bath air cleaners.

Pre-Cleaners

Pre-cleaners are devices that remove large particles of dirt or other foreign matter from the air before it enters the main air cleaner. This relieves most of the load on the air cleaner. Pre-cleaners are normally installed at the end of an air cleaner inlet pipe that extends upward into the air (fig. 1-34). This locates them in an area relatively free of dust.

NOTE: Cleaning out the collector bowl of the pre-cleaner is part of operator's maintenance and should be performed during both prestart and post-operation maintenance.

Dry Air Cleaners

Dry air cleaners (fig. 1-35) are attached directly to the intake system and are used on engines in which the

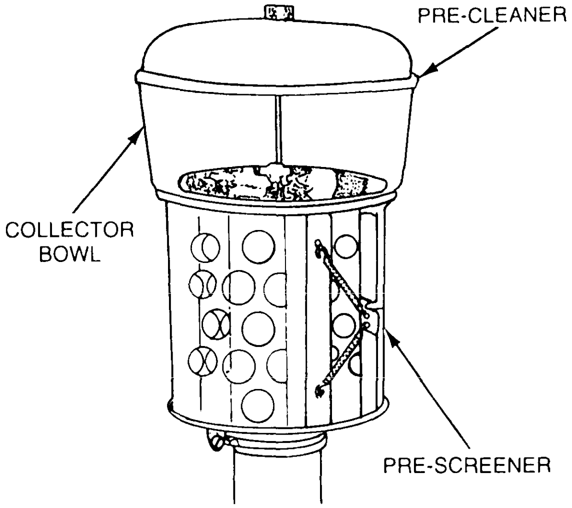


Figure 1-34.—Pre-cleaner.

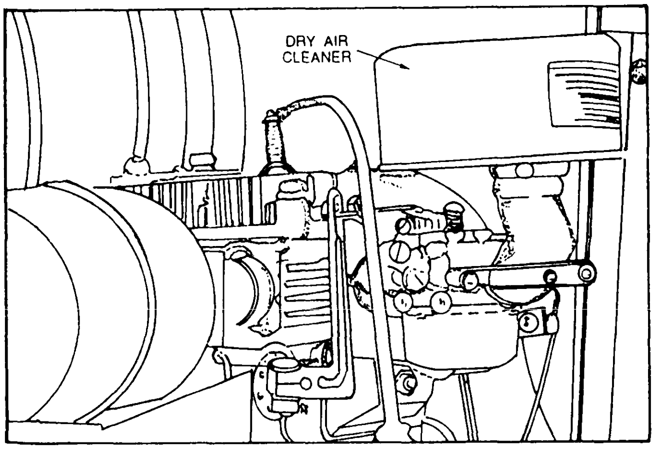
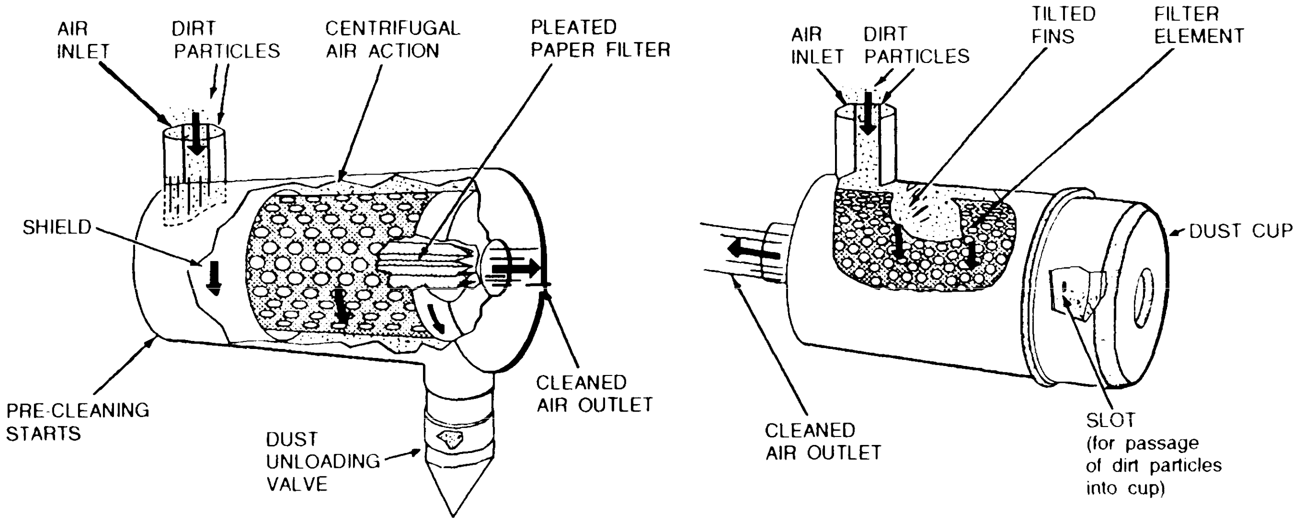


Figure 1-35.—Dry air cleaner.



A. DRY AIR CLEANER WITH UNLOADING VALVE

B. DRY AIR CLEANER WITH DUST CUP

Figure 1-36.-Dry-element air cleaner.

demand for air is small. The dry air cleaner cleans the air by passing it through layers of cloth or felt that removes large dirt particles from the air very effectively.

Dry-Element Air Cleaners

The two most common dry-element air cleaners used are the cleaner with an unloading valve and a cleaner with a dust cup (fig. 1-36).

Dry air cleaners are built for two-stage cleaning: pre-cleaning and filtering. The cleaner with the dust unloading valve, as shown in figure 1-36, view A, directs the air into the pre-cleaner so that it strikes one side of the metal shield. This starts the centrifugal suction that continues until it reaches the far end of the cleaner housing. At this point, the dirt is collected into the dust unloader valve located at the bottom of the housing.

The dust unloader valve is a rubber duck-bill device that is held closed by engine suction while the engine is running. When the engine is shut down, the weight of the accumulated dirt helps open the flaps so the dirt can drop out. The cleaner with the dust air cup, as shown in figure 1-36, view B, pulls in the air past tilted fins that starts the centrifugal suction. When the air reaches the end of the cleaner housing, the dirt passes through a slot in the top of the cleaner and enters the dust cup.

Both types of pre-cleaners remove over 80 percent of the dirt particles, greatly reducing the load on the filters. After the air goes through the pre-cleaning stage, it then passes through the holes in the metal jacket surrounding the pleated-paper filter. Filtering is performed as the air passes through the paper filter that filters out almost all of the remaining small particles.

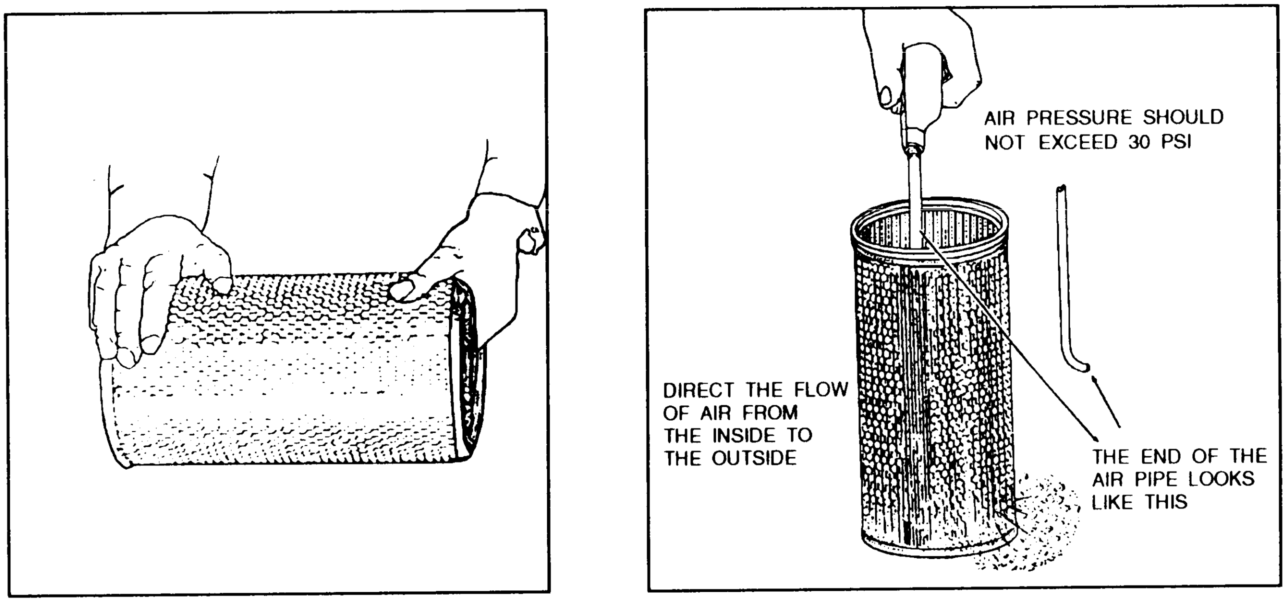
Checking and cleaning air cleaners equipped with either a dust unloading valve or dust cup is part of the daily prestart and post-operational checks and maintenance performed by the operator. The dust unloading valve should be inspected for cracks, clogging, and deterioration. The dust cup should be removed and wiped clean with a rag. Dusty filter elements should be removed and cleaned by tapping and rotating the filter on the heel of your hand to remove the dust.

NOTE: Do not tap the filter on a hard surface; this can damage the element.

When the tapping does not remove the dust, use a compressed air cleaning gun to clean the filter (fig. 1-37). Direct the clean dry air up and down the pleats, blowing from inside to outside.

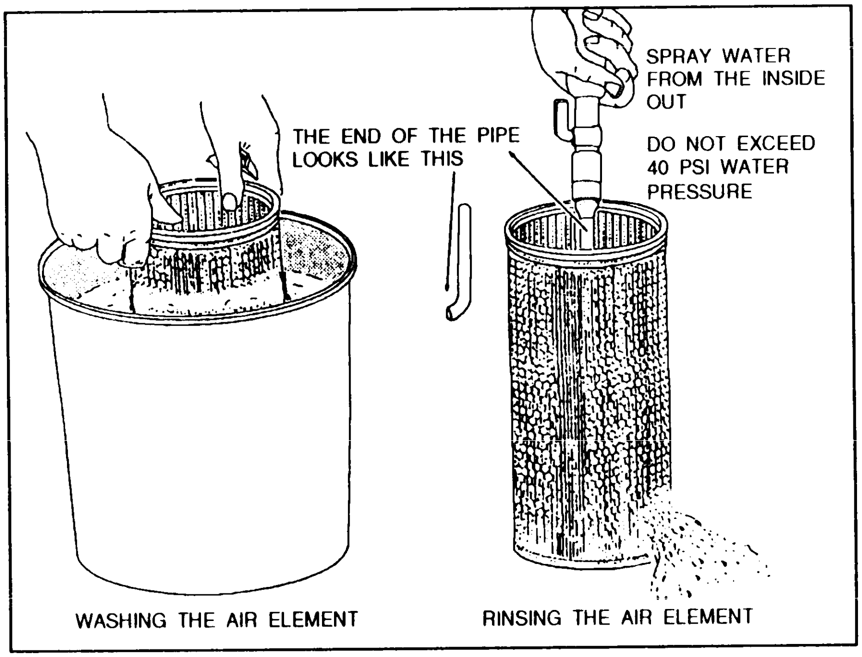
NOTE: To prevent rupturing the filter, you must not allow the compressed air pressure to exceed 30 psi.

To clean with water, you first blow out the dirt with compressed air, then flush the remainder of the dirt from inside to outside with water. After flushing is completed, allow the filter to dry.


AIR PRESSURE SHOULD NOT EXCEED 30 PSI
DIRECT THE FLOW OF AIR FROM THE INSIDE TO THE OUTSIDE
THE END OF THE AIR PIPE LOOKS LIKE THIS

PATTING THE ELEMENT

CLEANING AN AIR FILTER WITH LOW-PRESSURE AIR


SPRAY WATER FROM THE INSIDE OUT
THE END OF THE PIPE LOOKS LIKE THIS
DO NOT EXCEED 40 PSI WATER PRESSURE
WASHING THE AIR ELEMENT
RINSING THE AIR ELEMENT

CLEANING AN AIR FILTER WITH SOAP AND WATER

Figure 1-37.—Dry filter cleaning.

For extremely oily filters, clean the filters with the compressed air or flush them with clean water. Soak and gently agitate the filter in a filter cleaning solution and lukewarm water. Rinse the filter thoroughly with clean water and then shake the excess water from the filter and allow it to airdry. Protect the filter from freezing, and keep a spare element to use while the washed one is drying.

After the filter is clean, inspect it for damage and check the filter gasket for damage. Before installing the filter, you must clean the inside of the air cleaner body thoroughly with a clean, damp rag.

NOTE: Consult the maintenance supervisor for approval before washing any filter elements with water. Additionally, never wash a dry element in fuel oil,

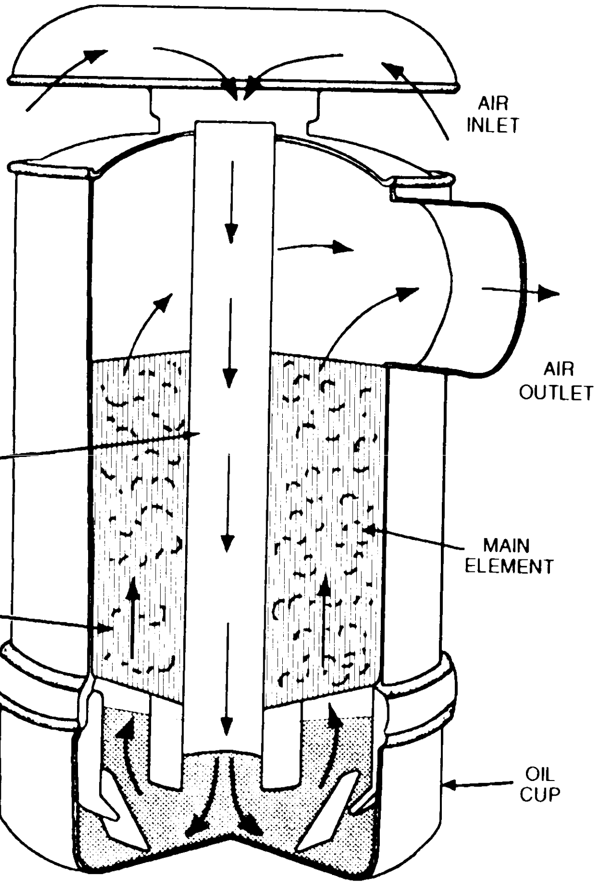

AIR
INLET
AIR
OUTLET
AIR
TUBE
MAIN
ELEMENT
INNER
OIL CUP
OIL
CUP

Figure 1-38.-Oil bath air cleaner.

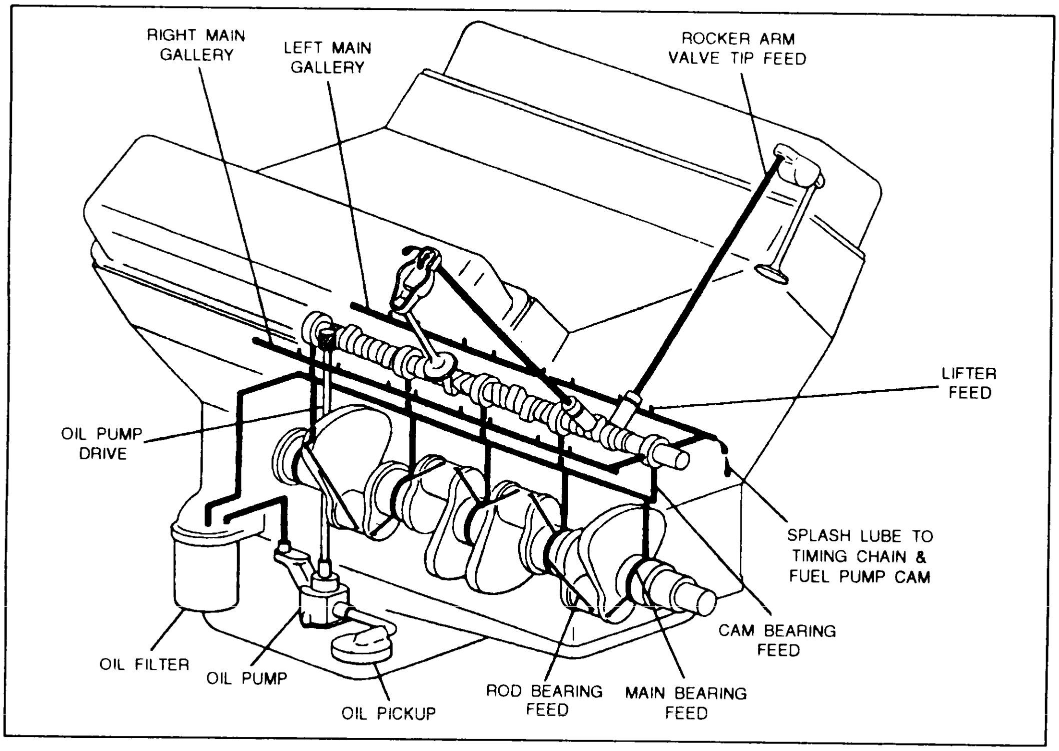

RIGHT MAIN
GALLERY
LEFT MAIN
GALLERY
ROCKER ARM
VALVE TIP FEED
LIFTER
FEED
OIL PUMP
DRIVE
SPLASH LUBE TO
TIMING CHAIN &
FUEL PUMP CAM
CAM BEARING
FEED
OIL FILTER
OIL PUMP
OIL PICKUP
ROD BEARING
FEED
MAIN BEARING
FEED

Figure 1-39.—Typical engine lubrication system.

gasoline, or solvent and never use compressed air to dry the element.

Oil Bath Air Cleaners

Oil bath air cleaners (fig. 1-38) draw air down a center tube where it strikes the surface of oil in the oil reservoir. As the air strikes the oil reservoir, most of the particles in the air do not make the 180-degree-upward turn. The dirt particles remain trapped in the oil. As the air continues upward and passes to the filter element, the smaller particles that bypassed the oil are trapped. The air keeps the filter element soaked with oil by creating a fine spray as it passes the reservoir. The air then makes another 180-degree turn and enters the intake system of the engine.

NOTE: It is the operator's responsibility to keep the oil cup filled to the proper level with the correct weight of oil and to document when the oil is dirty or has thickened, reducing its ability to clean particles from the air.

LUBRICATION SYSTEM

The engine lubrication system (fig. 1-39) reduces friction between moving parts, absorbs and dissipates heat, seals the piston rings and cylinder walls, cleans and flushes moving parts, and helps deaden the noise of the engine.

Checking the lubrication oils on a piece of equipment is part of the prestart check and the operator's responsibility. Also, it is a good professional practice to recheck the lube oil levels after a lunch break or during a crew turnover. The effort to check the lube oils is easier than explaining to the chain of command why an engine or part of the power train locked up or seized.

ENGINE OIL

Besides reducing friction and wear, engine oil acts as a cooling agent by absorbing heat from the surfaces over which it is spread. Engine oil carries heat to the engine sump where it is dissipated. The water circulating through an oil cooler also helps to reduce this heat (not all engines have oil coolers).

Engine oil is also used as a sealing agent. It fills the tiny openings between moving parts and cushions them against damage and distortion from extreme heat.

Engine oil is very important as a cleaning agent. Grit and dirt in engine parts are often removed by the oil before damage can result. The foreign matter and the greases in the bottom of the crankcase are evidence that engine oil cleans. Some oils have chemicals, known as additives, added to make them even better cleaners.

Oil Level Indicator

The oil level indicator consists of a rod, known as a dipstick. The dipstick extends through a tube into the crankcase (fig. 1-40). Marks on the dipstick indicate when the crankcase is full or, if low, how much oil is needed. To take readings, you should perform the following procedure: pull the dipstick out, wipe the dipstick with a rag, stick it back in, pull it out once again, and note how high the oil level is on it. On some engines, the correct oil level is achieved after the engine has

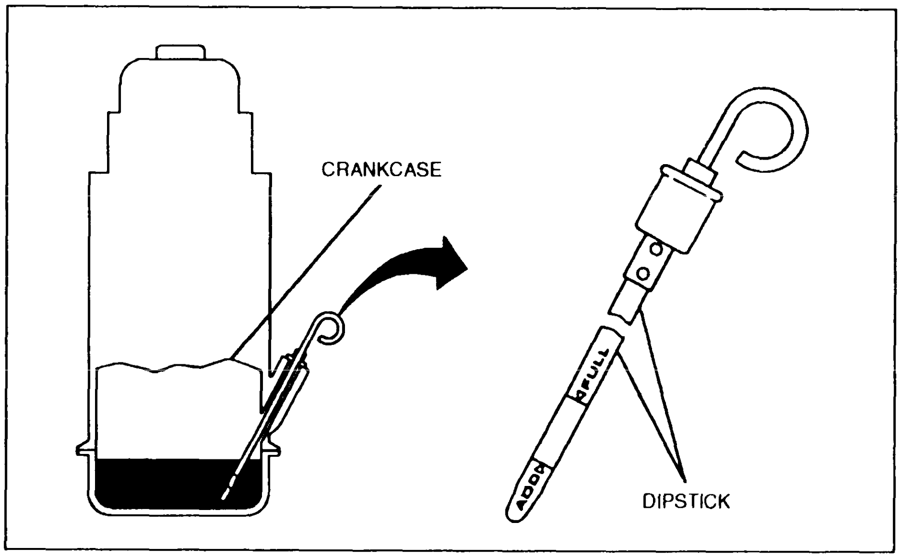


Figure 1-40.-Oil level indicator.

cycled a few minutes. However, it is a good practice to check to make sure there is oil in the crankcase, then follow the manufacturer's recommendations.

Oil Filters

The oil filter removes most of the impurities that were picked up by the oil as it circulated through the engine. Two types of filter element configurations are in use: the cartridge type and the sealed (spin-on) type (fig. 1-41).

CARTRIDGE FILTER.— The cartridge filter element fits into a permanent metal container. Oil is pumped under pressure into the container where it passes from the outside of the filter element to the center. From here the oil exits the container. The filter element is changed easily by removing the cover from the container.

SEALED (SPIN-ON) FILTER.— The sealed (spin-on) filter element is completely self-contained, consisting of an integral metal container and filter element. Oil is pumped into the container on the outside of the filter element. The oil then passes through the filter to the center of the element where it exits the container. This type of filter is screwed onto its base and is removed by spinning it off.

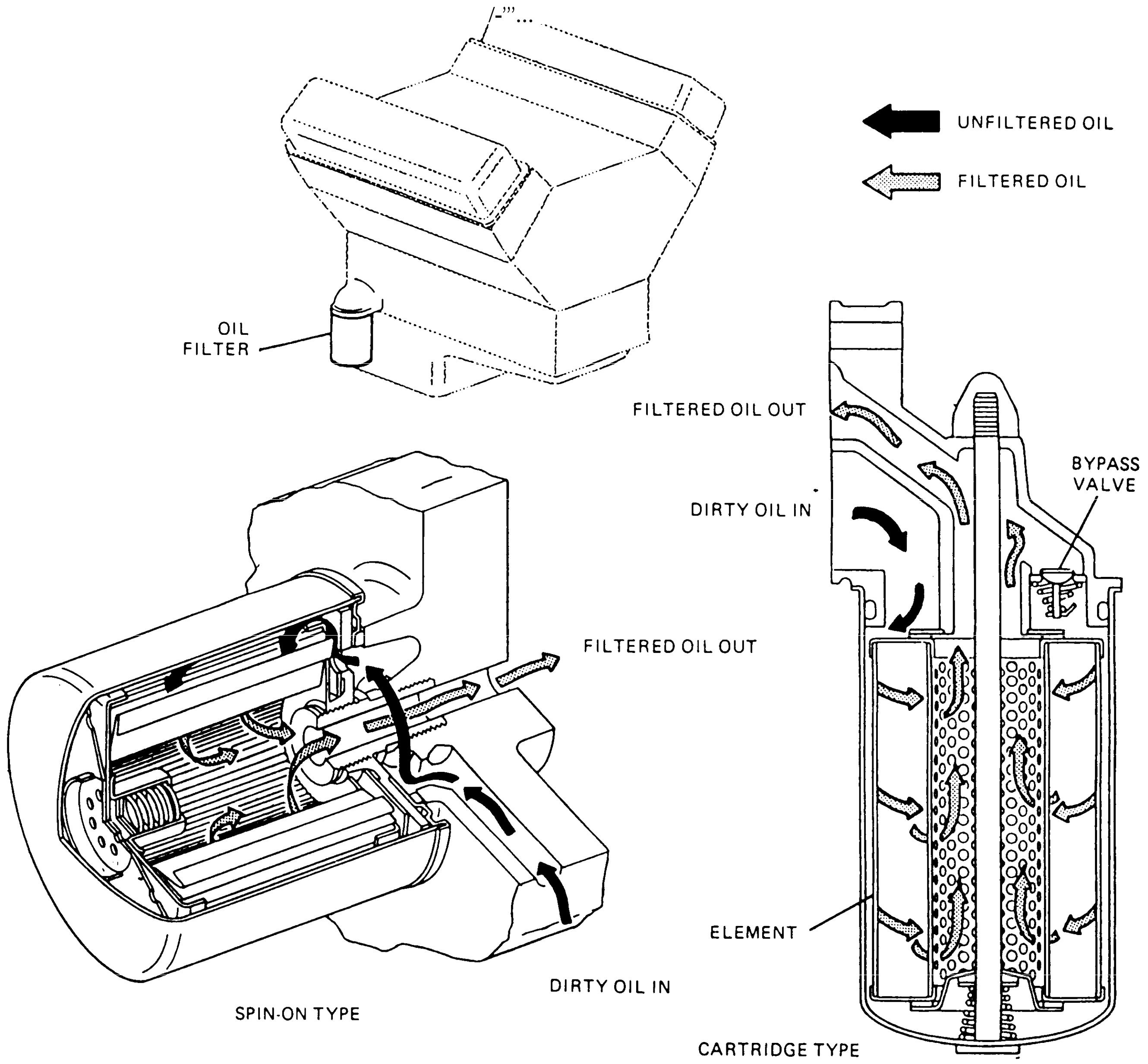
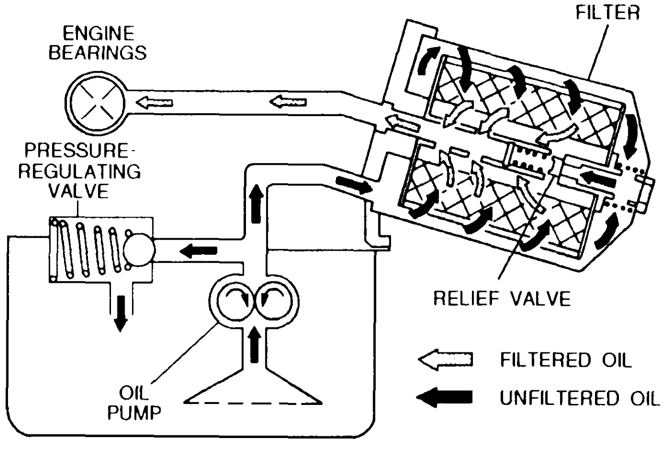
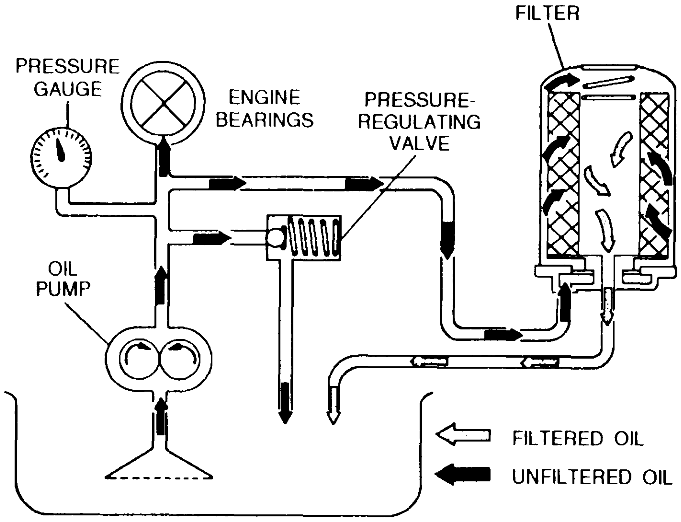

UNFILTERED OIL
FILTERED OIL
OIL FILTER
FILTERED OIL OUT
BYPASS VALVE
DIRTY OIL IN
FILTERED OIL OUT
ELEMENT
DIRTY OIL IN
SPIN-ON TYPE
CARTRIDGE TYPE

Figure 1-41.-Oil filters.



A. FULL-FLOW SYSTEM



B. BYPASS SYSTEM

Figure 1-42.-Filter system configurations.

Filtering Systems

Two filter system configurations are in use today: the full-flow system and the bypass system.

FULL-FLOW SYSTEM.— All the oil in the full-flow system (fig. 1-42, view A) is circulated through the filter before it reaches the engine. When this system is used, it is necessary to incorporate a bypass valve in the oil filter. This valve allows the oil to circulate through the system without passing through the element in the event that it becomes clogged. This factor prevents the oil supply from being cut off from the engine.

BYPASS SYSTEM.— The bypass system (fig. 1-42, view B) diverts only a small quantity of the oil each time it is circulated and returns it directly to the oil pan after it is filtered. This type of system does not filter the oil before it is sent to the engine.

HYDRAULIC FLUID

On equipment, hydraulic fluids are used for hydraulic systems that steer, lift, push, close, and so forth. Hydraulic fluids that are currently in use include mineral oil, vegetable oil, water, phosphate ester, ethylene glycol compounds, and oil in water. The three most common types of hydraulic fluids are water base, petroleum base, and synthetic base.

NOTE: Before adding hydraulic fluid in a piece of equipment, consult the operator's manual for the type of hydraulic fluid required. Using the incorrect type can contaminate the hydraulic system which requires that the system be drained, flushed, and refilled with the correct fluid.

GEAR OIL

Gear oils are used in both manual transmissions and differentials. Gear oils reduce friction and do not break down or foam at high temperatures.

NOTE: Before adding gear oil, consult the operator's manual for the type of oil required for the specific type of equipment. Mixing different types of gear oil may cause the oil to break down and not have the quality required to protect the gears.

GREASE

Grease is used to lubricate bearings, bushings, and pivot points. For inaccessible bearings, grease is applied under pressure by the use of a grease gun (fig. 1-43).

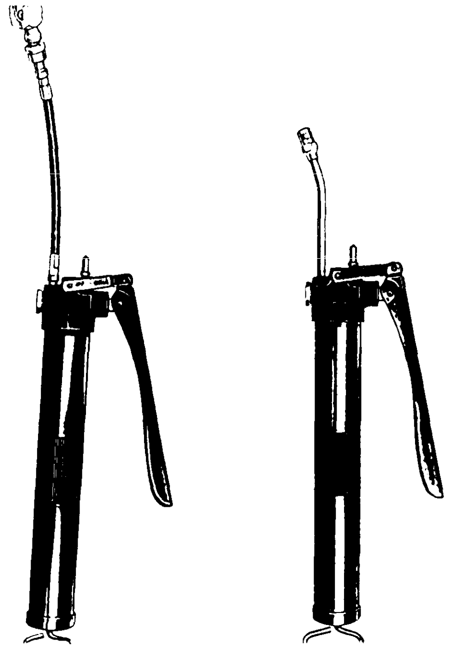


Figure 1-43.-Hand-operated grease gun.

When you are operating in dirty atmospheric conditions, grease seals out dust, dirt, and water from entering bearings and bushings.

Grease lube charts are either mounted on the equipment or are in the operator's manual. Grease lube charts state locations of grease fittings and how often the fittings should be lubricated. Over greasing of equipment blows seals and the excess grease collects sand and dirt that acts as a grinding compound on the lubricated surfaces. Under greasing allows excessive wear caused by metal-to-metal contact.

NOTE: Greasing equipment is the responsibility of the operator.

A water-resistant grease can prevent water from entering bearings and bushing joints. The grease commonly used on equipment is lithium-based. Lithium-based grease is water-resistant and has a wide range of operating temperatures. Care should be taken to keep grease clean. Always keep the grease container covered to prevent dirt and water from contaminating it.

ENGINE COOLING SYSTEMS

All internal combustion engines are equipped with some type of cooling system because of the high temperatures they generate during operation. The temperature in the combustion chamber during the burning of fuel is much higher than the melting point of iron. Therefore, if nothing is available to cool the engine during operation, valves burn and warp, lubricating oil breaks down, and bearings and pistons overheat resulting in engine seizure. At the same time, the engine must not be allowed to run too cold. An engine running cold does not burn all the fuel taken into the combustion chamber, causing carbon deposits to form that reduce fuel mileage, increase wear, and reduce engine power.

Three functions of the cooling system provide a satisfactory temperature operating range for the engine. First, the system removes the unwanted heat. Second, it regulates the engine temperature to keep it just right during all operating conditions. Third, when the engine is first started, the cooling system assists the engine in warming up to its normal operating temperature as soon as possible.

The two types of cooling methods are liquid cooling and air cooling. The liquid-cooling system is the most popular for automotive use, because it provides the most positive cooling and it maintains an even engine temperature. Air cooling is used for small vehicles and equipment; however, air cooling is not used if water cooling is practical. This is because air-cooled engines do not run at even temperatures and require extensive use of aluminum to dissipate heat.

Other means of heat dissipation for the engine, in addition to the cooling system, are as follows:

- The exhaust system dissipates as much, if not more, heat than the cooling system, although that is not its purpose.

- The engine oil removes heat from the engine and dissipates it to the air from the sump.

- The fuel provides some engine cooling through vaporization.

- A measurable amount of heat is dissipated as the air passes over the engine.

LIQUID-COOLING SYSTEM

A simple liquid-cooled cooling system consists of a radiator, water pump, hoses, fan and shroud, thermostat, and a system of jackets and passages in the cylinder head and cylinder block through which the coolant circulates (fig. 1-44). Cooling of the engine parts is accomplished by keeping the coolant circulating and in contact with the metal surfaces to be cooled. The pump draws the coolant from the bottom of the radiator, forces it through the jackets and passages, and ejects it into the upper tank on top of the radiator. The coolant then passes through a set of tubes to the bottom of the radiator from which the cooling cycle begins again. The radiator is situated in front of a fan that is driven either by the water pump or an electric motor. The fan ensures an air flow through the radiator at times when there is no vehicle motion.

Radiator

Most radiators have two tanks with a heat exchanging core between them. The upper tank contains an outside pipe, called an **inlet,** and on top is the **filler neck.** Attached to the filler neck is an outlet to the **overflow pipe.** The overflow pipe provides an opening from the radiator for escape of coolant or steam if pressure in the system exceeds the regulated maximum. This prevents rupture of cooling system components. The lower tank contains an outside pipe that serves as the outlet for the radiator.

The radiator is usually mounted in the front of the engine compartment so cool air can pass freely through the core. The outlet on the bottom radiator tank is connected to the water pump inlet. The top tank inlet of the radiator is connected to the outlet at the top of the engine. Rubber hoses and hose clamps are used to make

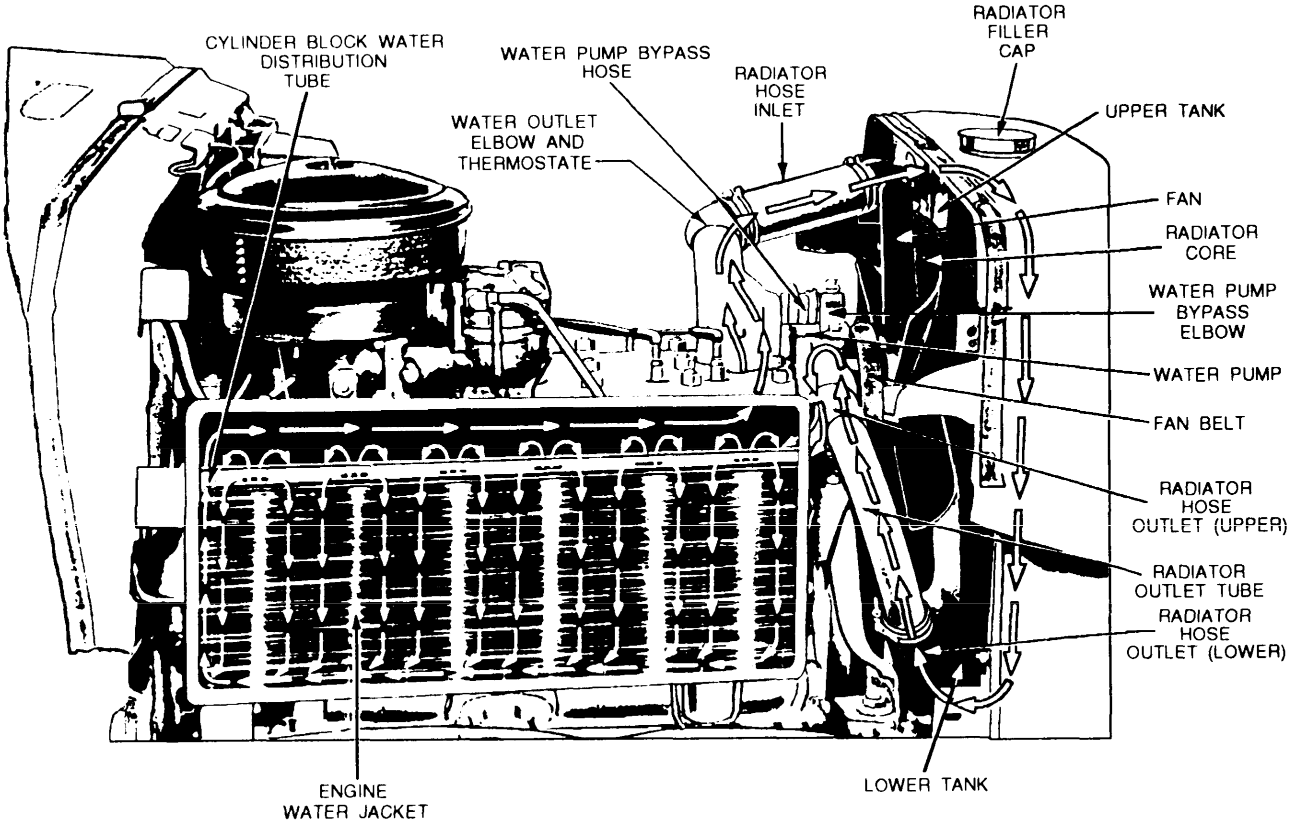

CYLINDER BLOCK WATER DISTRIBUTION TUBE
WATER PUMP BYPASS HOSE
WATER OUTLET ELBOW AND THERMOSTATE
RADIATOR HOSE INLET
RADIATOR FILLER CAP
UPPER TANK
FAN
RADIATOR CORE
WATER PUMP BYPASS ELBOW
WATER PUMP
FAN BELT
RADIATOR HOSE OUTLET (UPPER)
RADIATOR OUTLET TUBE
RADIATOR HOSE OUTLET (LOWER)
ENGINE WATER JACKET
LOWER TANK

Figure 1-44.—Liquid-cooling system.

these connections to prevent engine vibrations from being transferred to the radiator.

When performing prestart checks on the radiator system, check for leaks, particularly where the tanks are soldered to the core, because vibration and pulsation from pressure can cause fatigue of soldered joints or seams. Bent fins should be straightened and the radiator core checked for any obstructions, tending to restrict the air flow. Radiator air passages can be cleaned by blowing them out with an air hose in the direction opposite to the ordinary flow of air. Water can also be used to soften obstructions before applying the air blast. In any event, the cleaning gets rid of dirt, bugs, leaves, straw, and other debris that would otherwise clog the radiator and reduce its cooling efficiency.

CAUTION

Spraying high-pressure water to soften an obstruction on the radiator can cause damage to the fins and core.

All hoses and tubing should be checked for leakage and general condition. The leakage may often be corrected by tightening or replacing the hose clamps. Deteriorated hoses should be replaced to preclude future troubles; for example, hoses sometimes rot on the inside, allowing tiny fragments to flow through the system and become lodged in the radiator, tending to clog it and cause overheating. For this reason, all old, cracked, or spongy hose should be replaced as soon as the condition is discovered during the prestart checks.

RADIATOR PRESSURE CAP.— The radiator pressure cap (fig. 1-45) is used on nearly all modern

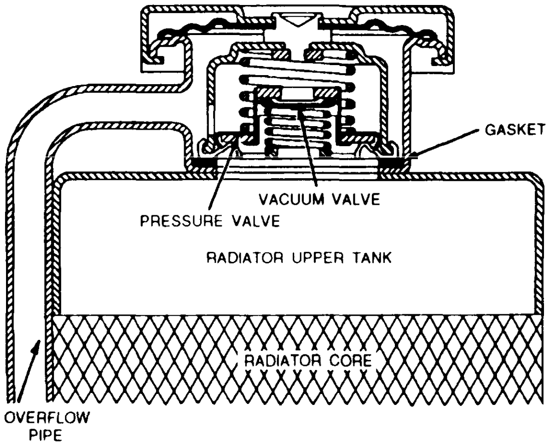

GASKET
VACUUM VALVE
PRESSURE VALVE
RADIATOR UPPER TANK
RADIATOR CORE
OVERFLOW PIPE

Figure 1-45.—Radiator pressure cap.

engines. The pressure cap closes off the overflow pipe and prevents loss of coolant during normal operation. It also allows a certain amount of pressure to develop within the cooling system. The pressure raises the boiling point of the coolant approximately 3 degrees for each pound and permits the engine to operate at higher temperatures without loss of coolant from boiling.

The pressure cap contains two spring-loaded valves. The larger valve is called the pressure valve and the smaller one is called the vacuum valve. A shoulder in the radiator filler neck provides a seat for the bottom of the cap assembly and a gasket on this seat prevents leakage between the cap and the filler neck.

The pressure valve acts as a safety valve to relieve extra pressure within the system. The cooling system may be designed to operate at various pressures between 4 and 17 psi, depending on the manufacturer's specifications. The pressure valve in the cap is preset by the manufacturer. When replacing a pressure cap, make sure you use a cap with the proper pressure setting that is usually marked on the top surface of the cap.

The vacuum valve opens only when the pressure within the cooling system drops below the outside air pressure as the engine cools down. This automatic action of the vacuum valve prevents collapse of the hoses and the radiator.

CAUTION

ALWAYS REMOVE THE RADIATOR CAP SLOWLY AND CAREFULLY. Removing the cap from a hot, pressurized radiator can cause serious burns from escaping steam and coolant.

COOLANT AND ANTIFREEZE.— Since water is easily obtained, is cheap, and has the ability to transfer heat readily, it has served as a basic coolant for many years. Some properties of water, such as the boiling point, freezing point, and natural corrosive action on metals, limit its usefulness as a coolant. This is counteracted by the use of an antifreeze. Manufactured under many different trade names, the most commonly used type of antifreeze is ethylene glycol. Ethylene glycol is a chemical compound composed of a mixture of ethylene and glycerine derivatives. Maximum freezing protection is achieved by mixing 60% ethylene glycol with 40% water. This mixture protects the cooling system to a temperature as low as minus 62°F. Ethylene glycol has a very high boiling point, does not evaporate easily, is noncorrosive, and is practically nonflammable.

WARNING

Because it has a sweet taste, animals and children sometimes ingest spilled coolant. The lead content that antifreeze absorbs while in use makes it a hazardous waste and it cannot be disposed of by being dumped on the ground. It must be containerized and turned in for disposal.

Water Pump

The water pump is the heart of the cooling system. Most engines use a centrifugal water pump (fig. 1-46) that provides a large volume capacity and is nonpositive in displacement. This type of pump has an impeller with blades that force the coolant outward as the impeller rotates. The shaft on which the impeller is mounted is usually driven by a fan belt and revolves in a bushing or in ball bearings inside the housing. For different cooling systems, pumps vary considerably in construction of seals, bearings, mounting, and drive.

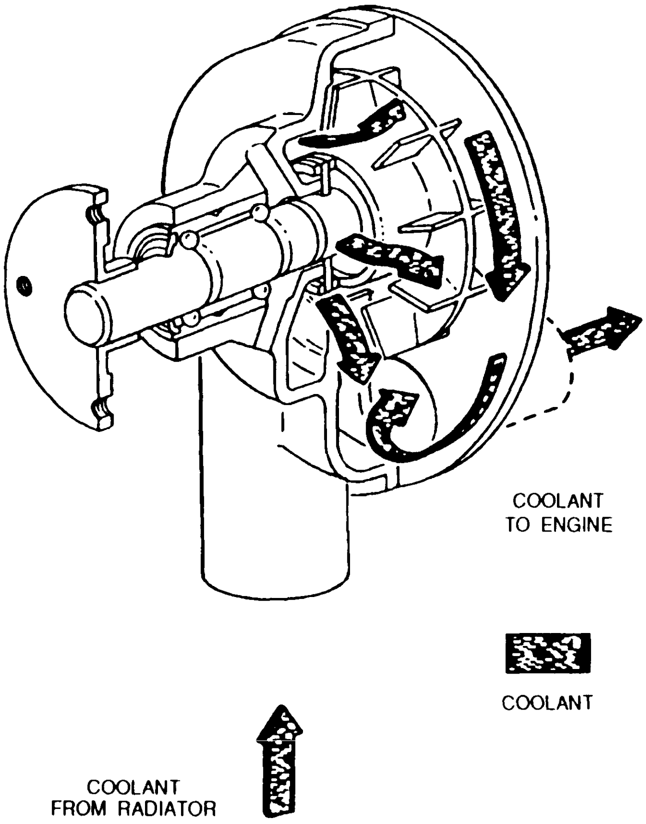


Figure 1-46.-Water pump.

Fan and Shroud

The engine fan is usually mounted on the end of the water pump shaft and is driven by the same belt that drives the pump. The fan pulls a large volume of air through the radiator core that cools the hot water circulating through the radiator. In addition to removing the heat from the water in the radiator, the flow of air created by the fan causes some direct cooling of the engine itself. On some construction equipment, such as dozers and track loaders, the fan blows air through the radiator vice pulling the air. Besides cooling the water, the blowing of air keeps sand, dirt, and debris out of the radiator. Some engines are equipped with a shroud that improves fan efficiency by assuring that all the air handled by the fan passes through the radiator.

Fan blades are spaced at intervals around the fan hub to aid in controlling vibration and noise. They are often curled at the tip to increase their ability to move air. Except for differences in location around the hub, most blades have the same pitch and angularity.

Bent fan blades are a common problem. They cause noise, vibration, and excess wear on the water pump shaft. Visual inspection of the fan blades, pulleys, pump shaft end play, and drive belts are part of your pre- and post-operational checks. A bent or distorted fan or one with a loose blade should be replaced. When the fan is merely loose on its mounting, tightening is in order. Loose fan belts can be adjusted for proper tension, usually by adjusting the generator or alternator on its mounting (fig. 1-47). A common method for measuring belt tension is to press down on the belt at a point midway between the generator or alternator and the fan pulley, and measure the amount of deflection. The amount of deflection varies and should be set to the manufacturer's specification. A rule of thumb used in the NCF for belt tension is no more than a one-half inch deflection.

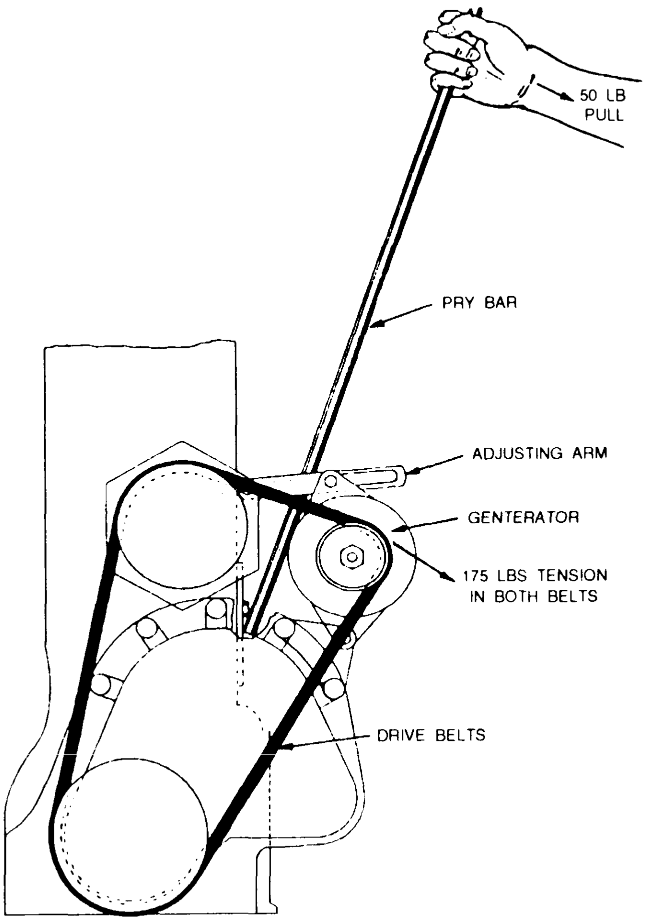


Figure 1-47.-Drive belt adjustment.

Water Jacket

The water passages in the cylinder block and cylinder head form the engine water jacket. The passages of the water jacket are designed to control circulation of coolant and provide proper cooling throughout the engine. In the cylinder block, the water jacket completely surrounds all cylinders along their full length. Water passages are also provided around the valve seats and hot parts of the cylinder block. In the cylinder head, the water jacket covers the combustion chambers at the top of the cylinders and contains passages around the valve seats when the valves are located in the head.

Thermostat

Automatic control of the temperature of an engine is necessary for efficient engine performance and economical operation. Since all engine parts are in a contracted state when cold, the engine temperature should be brought to normal as quickly as possible. The water pump starts coolant circulating the moment the engine is started, which is undesirable during cold weather operations. Coolant circulation is restricted by the installation of a thermostatically controlled valve, or thermostat, in the cylinder head water outlet. This valve allows coolant to circulate freely only within the block until the desired temperature is reached. This shortens the warm-up period. A bypass is used to direct the water

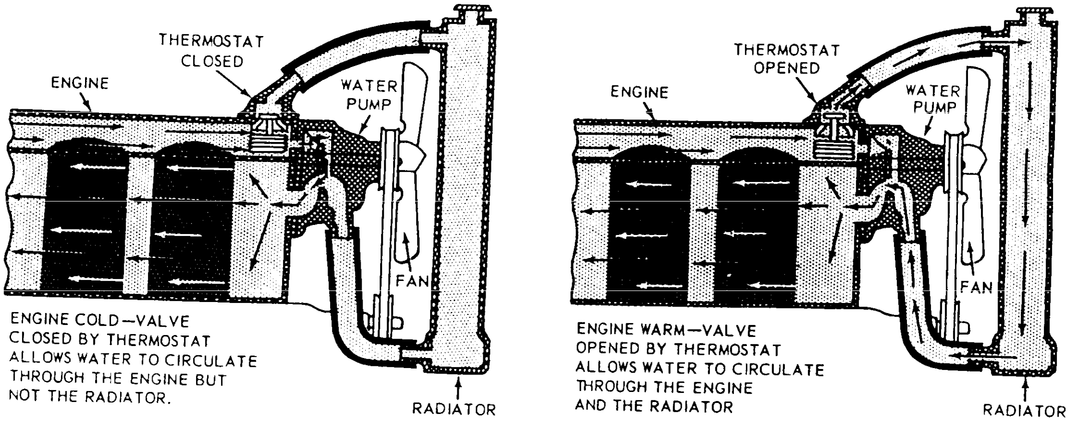

THERMOSTAT CLOSED
ENGINE
WATER PUMP
FAN
ENGINE COLD—VALVE CLOSED BY THERMOSTAT ALLOWS WATER TO CIRCULATE THROUGH THE ENGINE BUT NOT THE RADIATOR.
RADIATOR
THERMOSTAT OPENED
ENGINE
WATER PUMP
FAN
ENGINE WARM—VALVE OPENED BY THERMOSTAT ALLOWS WATER TO CIRCULATE THROUGH THE ENGINE AND THE RADIATOR
RADIATOR

Figure 1-48.-Thermostat operation.

from the block to the pump when the passage to the radiator is blocked by the closed thermostat (fig. 1-48).

Some stationary engines and large trucks are equipped with shutters that supplement the action of the thermostat in providing a faster warmup and in maintaining proper operating temperatures. When the engine coolant is below a predetermined temperature, between 185°F to 195°F, the shutters, located in front of the radiator, remain closed and restrict the flow of air through the radiator. Then, as the coolant reaches proper temperature, the shutters start to open.

Overflow Tank

The overflow tank serves as a receptacle for coolant forced out of the radiator overflow pipe and provides for its return to the system. As the engine cools, the balancing of pressures causes the coolant to siphon back into the radiator.

Cooling systems using an overflow tank are known as closed cooling systems (fig. 1-49). Coolant is usually added to this system through the overflow tank that is marked for proper coolant level. **NEVER** remove the radiator cap located on the radiator unless you are positive the system is cold. If there is any pressure in the radiator, it will spray you with hot steam and coolant. Use extreme caution when performing operator's maintenance on a closed cooling system.

Expansion Tank

Some engines use an expansion tank in their cooling system (fig. 1-50). The tank is mounted in series with the upper radiator hose and is used to supply extra room for coolant expansion and generally takes the place of the upper radiator tank. The pressure cap and the overflow line are also mounted on the expansion tank.

AIR-COOLING SYSTEM

The simplest type of cooling is the air-cooled, or direct method, in which the heat is drawn off by moving air in direct contact with the engine. The rate of the cooling is dependent upon the area exposed to the cooling air, the heat conductivity of the metal used, the volume of the metal or its size in cross section, the amount of air flowing over the heated surfaces, and the difference in temperature between the exposed metal

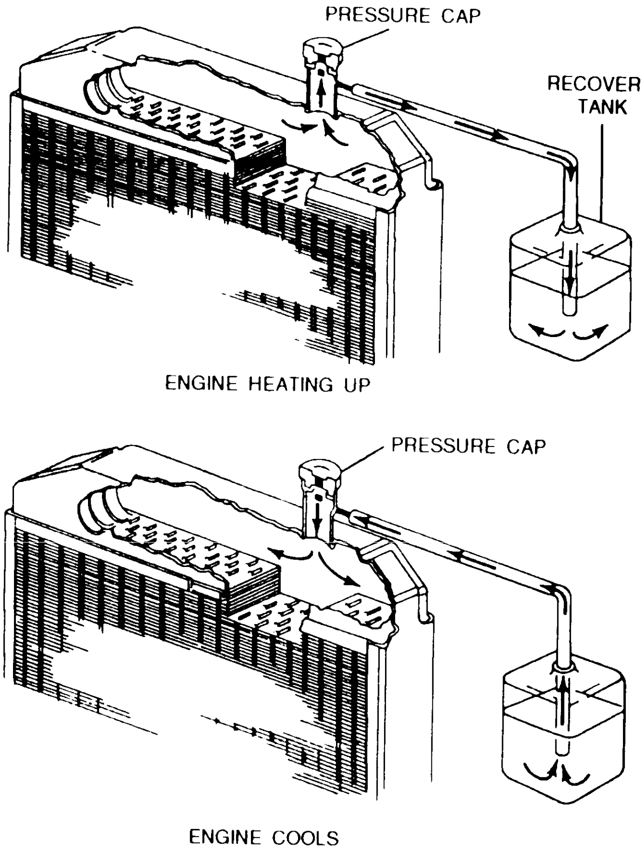

PRESSURE CAP
RECOVERY TANK
ENGINE HEATING UP
PRESSURE CAP
ENGINE COOLS

Figure 1-49.-Closed cooling system.

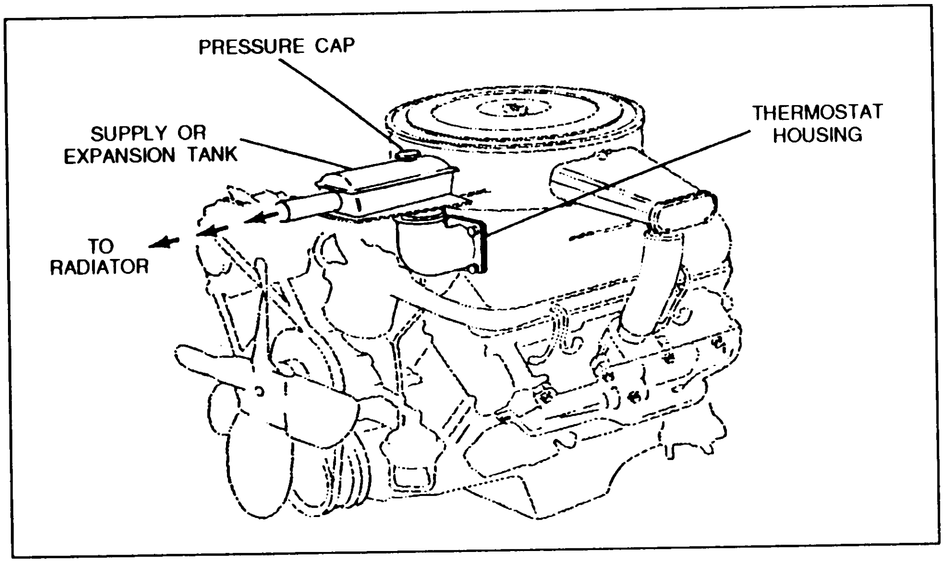

PRESSURE CAP
SUPPLY OR EXPANSION TANK
THERMOSTAT HOUSING
TO RADIATOR

Figure 1-50.-Expansion tank.

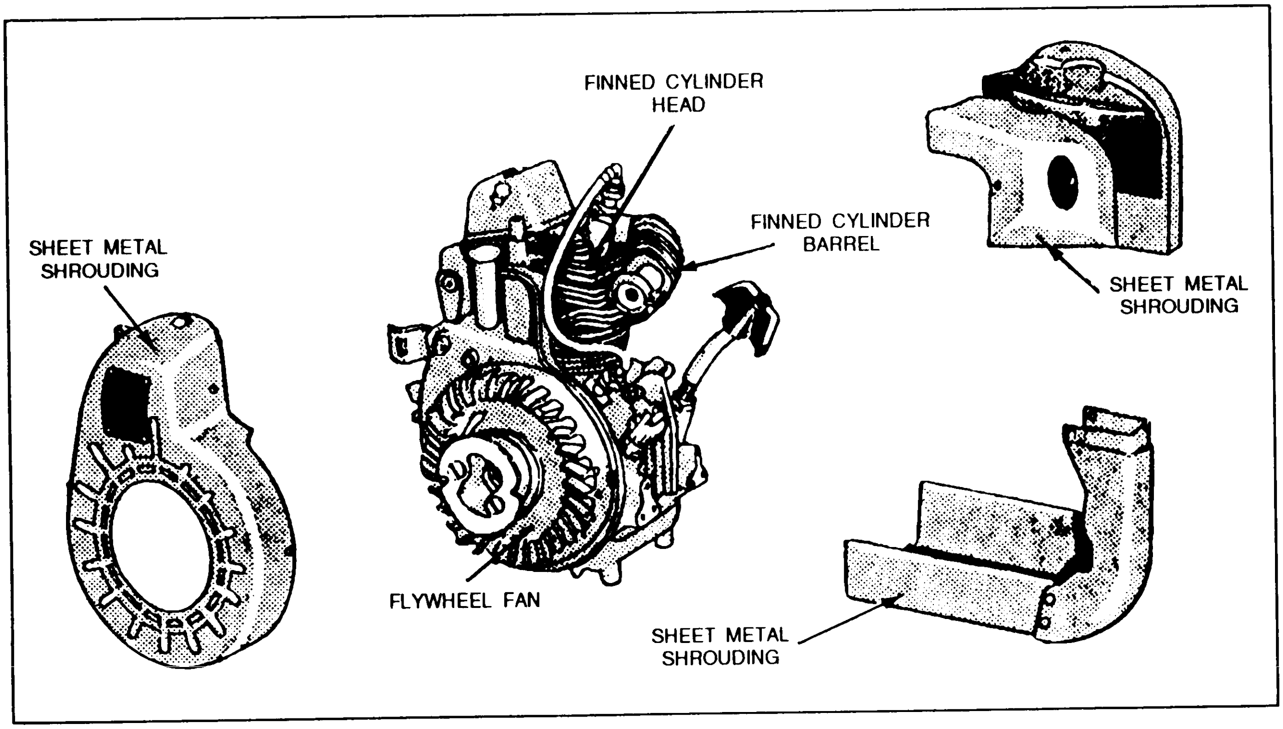

FINNED CYLINDER HEAD
SHEET METAL SHROUDING
FINNED CYLINDER BARREL
SHEET METAL SHROUDING
FLYWHEEL FAN
SHEET METAL SHROUDING

Figure 1-51.—Air-cooled engine.

surfaces and the cooling air. Some heat must be retained for efficient operation. This is accomplished by the use of thermostatic controls and mechanical linkage that open and close shutters to control the volume of cooling air. You will find that air-cooled engines generally operate at a higher temperature than liquid-cooled engines, whose operating temperature is largely limited by the boiling point of the coolant used. Consequently, greater clearances must be provided between the moving parts of air-cooled engines to allow for the increased expansion.

In air-cooled engines, the cylinders are mounted independently to the crankcase so that an adequate volume of air can circulate directly around each cylinder. The circulating air absorbs excessive amounts of heat from the cylinders and maintains enough cylinder head temperatures for satisfactory operation. The cooling action is based on the simple principle that the surrounding air is cooler than the engine heat. The primary components of an air-cooled system are the fan and shroud and the baffles and fins. A typical air-cooled engine is shown in figure 1-51.

Fan and Shroud

All stationary air-cooled engines must have fans or blowers of some type to circulate a large volume of cooling air over and around the cylinder. The fan for the air-cooled engine shown in figure 1-51 is built into the flywheel. When the engine is assembled, the shrouding, or cowling, forms a compartment around the engine so that the cooling air is properly directed for effective cooling. Air-cooled engines, such as those used on motorcycles and outboard engines, do not require the use of fans or shrouds, because their movement through the air creates a sufficient air flow over the engine for adequate cooling.

Baffles and Fins

In addition to the fan and shroud, some engines use baffles or deflectors to direct the cooling air from the fan to those parts of the engine not in the direct path of air flow. Most baffles are made of light metal and are semicircular with one edge in the stream of air. Most air-cooled engines use fins. These are thin, raised projections on the cylinder barrel and head. The fins provide more cooling area or surface and aid in directing air flow. Heat, resulting from combustion, passes by conduction from the cylinder walls and cylinder head to the fins and is carried away by the passing air.

CHAPTER 2

POWER TRAIN

The heart of the power train is the internal combustion engine that provides the power required to move a vehicle. However, this task is made much more efficient with the aid of the transmission and the other drive-line components that make up the power train (fig. 2-1). This chapter covers the basic principles of manual and automatic transmissions, propeller shaft assemblies, and final drives.

TRANSMISSIONS

Power from the engine provides the torque required for the transmission to overcome inertia. Inertia is a property of matter by which it remains at rest or in uniform motion in a straight line unless acted upon by some external force. In this case, the inertia of the vehicle at rest is overcome by an external force—the engine power in the form of torque. Once the vehicle is moving, acceleration begins and increases and very little torque is then required. The bigger the load on the engine, the bigger and more efficient the transmission must be. Once a vehicle gains the desired speed, it moves along with very little effort until something is encountered, such as a grade in the road, that increases the resistance to its movement. Now torque is required again and the operator has to select a lower gear.

The transmission (fig. 2-2) provides the mechanical advantage that enables the engine to move the vehicle. It allows the operator to control the power and speed of the vehicle and allows disengaging and reversing the flow of power from the engine to the wheels by means of a clutch.

CLUTCH

The clutch engages and disengages the engine crankshaft to or from the transmission and the rest of the power train. Engine power to the load must be applied slowly to allow a smooth engagement and to lessen shock on the driving and driven parts. After engagement, the clutch must transmit the engine power to the transmission without slipping. Additionally, the engine must be disconnected from the power train in order to shift gears.

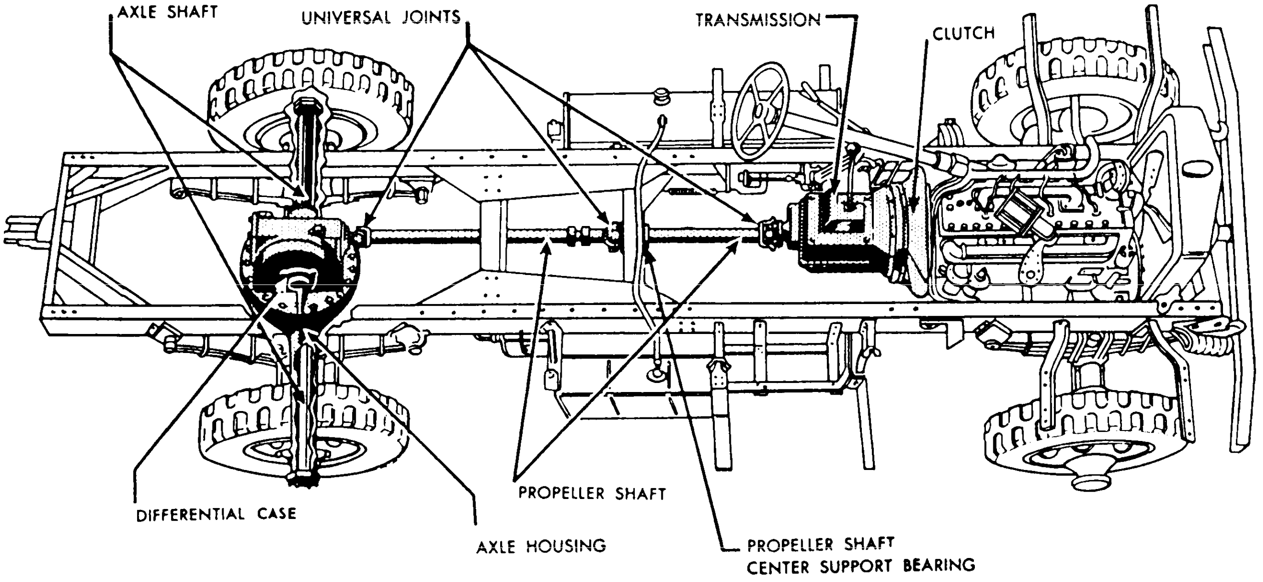


Figure 2-1.-Typical power train.

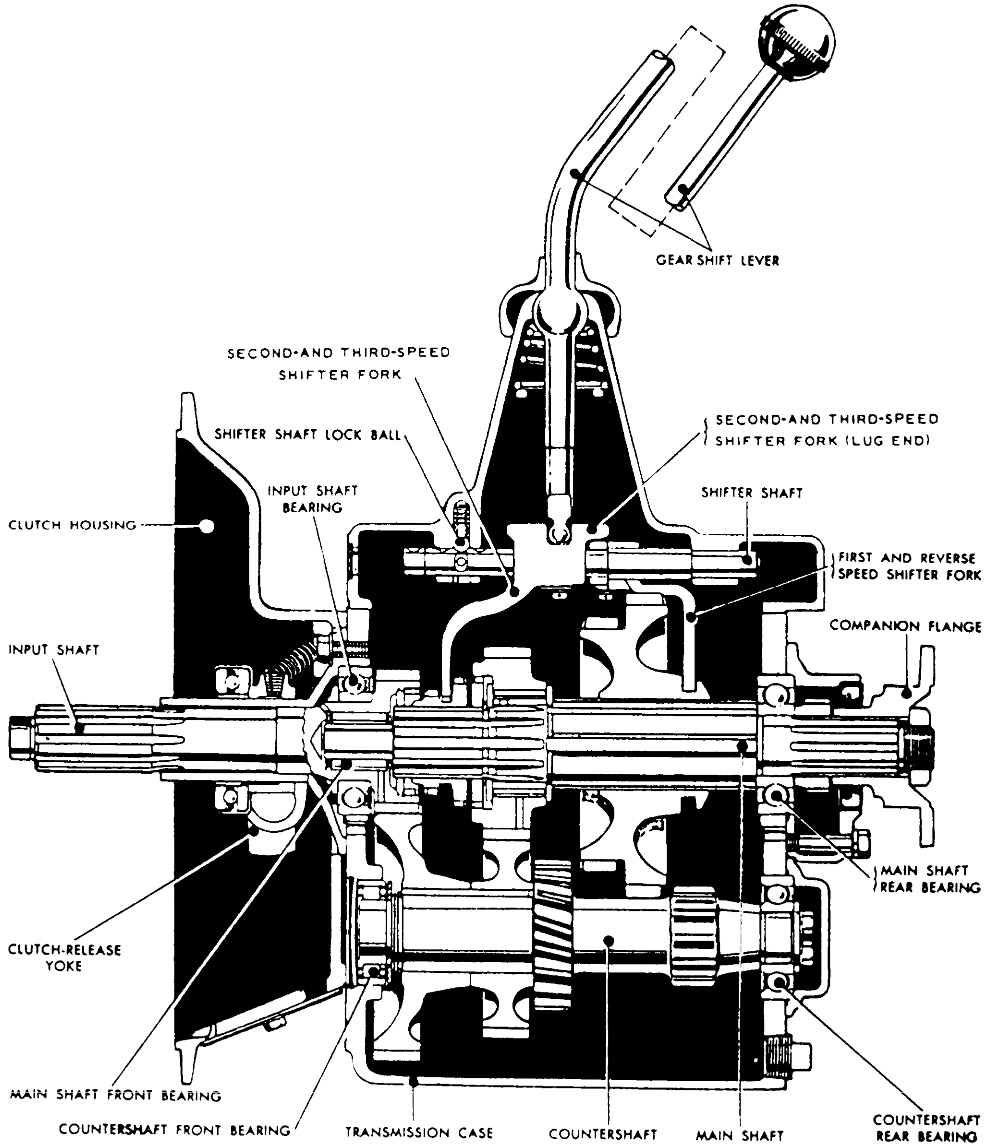

GEAR SHIFT LEVER
SECOND-AND THIRD-SPEED SHIFTER FORK
SHIFTER SHAFT LOCK BALL
SECOND-AND THIRD-SPEED SHIFTER FORK (LUG END)
INPUT SHAFT BEARING
SHIFTER SHAFT
CLUTCH HOUSING
FIRST AND REVERSE SPEED SHIFTER FORK
COMPANION FLANGE
INPUT SHAFT
MAIN SHAFT REAR BEARING
CLUTCH-RELEASE YOKE
MAIN SHAFT FRONT BEARING
COUNTERSHAFT FRONT BEARING
TRANSMISSION CASE
COUNTERSHAFT
MAIN SHAFT
COUNTERSHAFT REAR BEARING

Figure 2-2.—Typical manual shift transmission.

Clutches transmit power from the clutch driving member to the driven member by friction. In the **DISC CLUTCH** (fig. 2-3), the driving plate secured to the engine flywheel gradually contacts the driven member (disc) attached to the transmission input shaft. The contact is made and held by strong spring pressure controlled by the operator with the clutch pedal (fig. 2-4). With only light spring pressure, there is little friction between the two members, and the clutch can slip; therefore, do not use the clutch pedal as a footrest. As the spring pressure increases, friction also increases, and less slippage occurs. When the operator's foot is removed from the clutch pedal and the full spring pressure is applied the speed of the driving plate and driven disc is the same and all slipping stops. The flywheel and the transmission input shaft are then connected.

Improper adjustment can damage or ruin a clutch. Figure 2-5 shows the proper free travel and linkage. Several clutch troubles may occur during vehicle operation that should be documented and turned in before too much damage occurs. These troubles include incorrect free travel, slipping, chattering, or grabbing when engaging; spinning or dragging when engaged; and clutch noises.

MANUAL TRANSMISSION

The transmission is located at the rear of the engine between the clutch housing and the propeller shaft. The

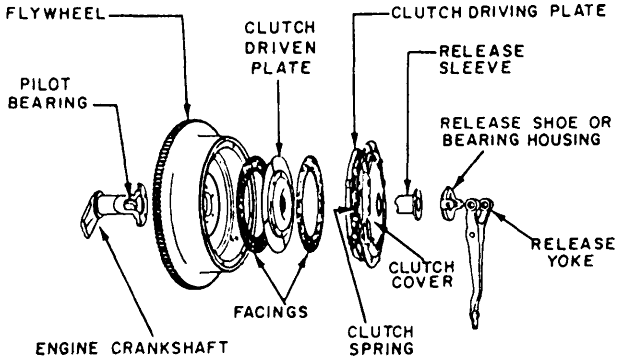

FLYWHEEL
CLUTCH DRIVEN PLATE
CLUTCH DRIVING PLATE
RELEASE SLEEVE
PILOT BEARING
RELEASE SHOE OR BEARING HOUSING
RELEASE YOKE
CLUTCH COVER
FACINGS
CLUTCH SPRING
ENGINE CRANKSHAFT

Figure 2-3.-Cross section of a disc clutch.

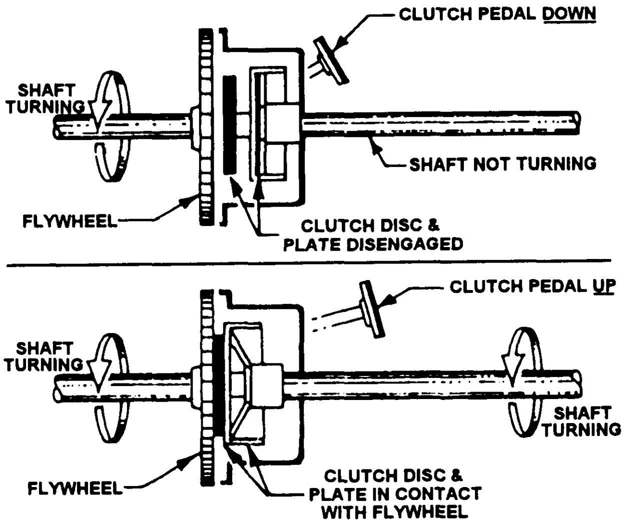

CLUTCH PEDAL DOWN
SHAFT TURNING
SHAFT NOT TURNING
FLYWHEEL
CLUTCH DISC & PLATE DISENGAGED
CLUTCH PEDAL UP
SHAFT TURNING
SHAFT TURNING
FLYWHEEL
CLUTCH DISC & PLATE IN CONTACT WITH FLYWHEEL

Figure 2-4.-Disc clutch operation.

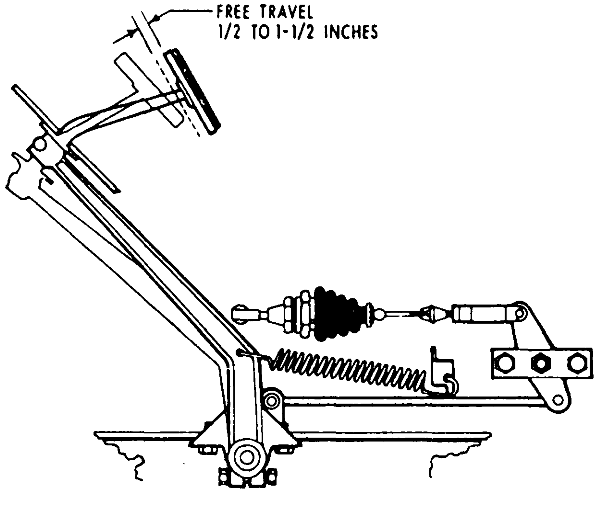

FREE TRAVEL
1/2 TO 1-1/2 INCHES

Figure 2-5.-Clutch linkage.

transmission transfers engine power from the clutch shaft to the propeller shaft and allows the operator to change the gear ratio between the engine and the rear wheels.

Dual-ratio, or two-speed rear axles are often used on trucks. They have two gear ratios that can be chosen by the operator, usually by a manual control lever. A dual-ratio rear axle works the same as the auxiliary transmission; it doubles the number of gear ratios for driving the vehicle under the various loads and on different roads.

The most common transmission type is the synchromesh transmission. The synchromesh transmission is basically a constant mesh, collar-shift transmission with an extra device, called a synchronizer, to equalize the speed of the mating parts before they engage. The synchronizer is used in all manual automotive transmissions and is common in other equipment where shifting while moving is required.

Part of the prestart operation is to check the fluid level in the manual transmission. The normal level of lubricant is usually at the bottom of the filler plug opening. When lubricant is needed, you should always check the operator's manual for the location and type of lubricant required for the transmission. When you keep the lubricant level correct, the gear teeth are protected, foam is reduced, and the transmission runs smoothly.

Some transmission troubles that you may encounter and must document are as follows:

- Hard shifting
- Slipping out of gear
- No power through the transmission
- Transmission noisy when in gear
- Gear clash in shifting
- Oil leaks

Manual Shift Operation

Skill in manual shifting is a requirement of professional driving. Poor manual shifting results in poor vehicle performance and can cause vehicle damage. Know the gearshift lever positions so well that you can shift to any gear without looking at the shift lever. The gearshift pattern is usually diagramed in the vehicle or in the operator's manual. Never move the gearshift lever from one position to another while the engine is running until you have fully depressed the clutch pedal with your left foot. To shift gears smoothly and quietly, you must keep the pedal fully depressed until the shift has been completed.

You should understand that the clutch provides the means of applying engine power to the wheels smoothly and gradually. To be a professional operator, you must learn just where the clutch starts to engage, how far the pedal must move to become fully engaged how much free play there is in the pedal, and how fast you should engage the clutch.

Keep your foot off the clutch pedal except when actually starting, stopping, or shifting gears. Even the slight constant pressure on the clutch pedal causes excessive wear. For the same reason, when stopped on a hill, never slip your clutch to keep from rolling backward; instead, use the brakes. Depress the clutch pedal and shift the transmission shift lever into neutral while waiting for a long traffic light or when halted for other reasons. Release the clutch after shifting into neutral.

When slowing your vehicle to stop or make a turn, be sure to reduce the vehicle speed to 15 miles per hour or less before depressing the clutch pedal. Coasting a vehicle at a high rate of speed with the clutch pedal depressed is dangerous, because control becomes more difficult and damage to the clutch may occur. This kind of practice is abusive to the vehicle.

CLUTCH SHIFTING.— After the prestart operation has been performed and you have acquainted yourself with the instruments and controls of the vehicle, warm the engine with the transmission in neutral. Start the vehicle moving with the transmission in low or first gear by following these steps:

1. Depress the clutch pedal and shift into low gear.

2. Check the mirrors, check blind spots, and give signals as required.

3. Let the clutch pedal up slowly, pausing at the friction point or when you feel it taking hold. Again, recheck the mirrors for traffic.

4. Release the parking brake and slowly release the clutch pedal, and at the same time, slightly depress the accelerator.

5. When the driving operation is under way, remove your left foot completely from the clutch pedal.

DOUBLE-CLUTCH SHIFTING.— Professional driving practice in trucks (1 1/2 ton or larger) often requires double clutching to permit proper engagement of the gears and to prevent loss of momentum. To shift to a lower gear by double clutching, follow these steps:

1. Release the pressure from the accelerator as you begin depressing the clutch pedal.

2. When the clutch pedal is fully depressed, move the gearshift lever to neutral position

3. Release the clutch pedal, and at the same time, depress the accelerator to speed up the engine.

4. Letup on the accelerator and depress the clutch pedal.

5. While the pedal is depressed move the gearshift lever to the next lower gear.

6. Release the clutch pedal, and at the same time, depress the accelerator to maintain engine speed as the load is again connected to the engine by the engagement of the clutch.

The procedure is the same for shifting to a higher gear speed, except that the engine is *NOT accelerated* while the transmission is in neutral.

CAUTION

> When you are shifting gears in rough terrain and on hills, never let your vehicle slow down to a point where the engine begins to labor or jerk before shifting into a lower gear ratio. Always anticipate the need for extra power and shift gears accordingly. When descending a hill, with or without a heavy cargo load, always drive with your vehicle in gear and the clutch pedal out.

NOTE: You may encounter vehicles that may have more complicated transmissions, such as multigear ranges, dual-speed axles, or other special features. As an operator, read and understand the operator's manual pertaining to a particular vehicle before attempting to operate it.

AUTOMATIC TRANSMISSION

The automatic transmission, like the manual transmission, is designed to match the load requirements of the vehicle to the power and speed range of the engine. However, the automatic transmission (fig. 2-6) performs this automatically, depending on the throttle position, vehicle Speed, and position of the shift control lever. Automatic transmissions are manufactured in models that have two, three, four, or more forward

2-8speeds and some are equipped with overdrive. Operator control is limited to the selection of the gear range by moving a control lever.

Part of the prestart operation is to check the transmission fluid level when the engine is idling and at normal operating temperature, when the vehicle is level, and when the transmission control lever is in park. The transmission fluid is used as a combination power transmission medium, hydraulic control fluid, heat transfer medium, bearing surface lubricant, and gear lubricant. The manufacturer's recomendations must be followed when servicing and filling the transmission with fluid.

CAUTION

Do not overfill the transmission because overfilling causes foaming and shifting troubles.

Some transmission troubles you may encounter and must document are as follows:

- No drive in any selected positions.
- On standstill starts the engine speed accelerates but the vehicle movement lags.
- Engine speed accelerates during upshifts.
- Transmission will not upshift.
- Upshift and downshift are harsh.
- Vehicle creeps too much in drive.
- Vehicle creeps in neutral.
- Improper shift points.
- Unusual transmission noise.
- Oil leaks.

Fluid Couplings

In the past, fluid couplings were widely used with automatic transmissions. Fluid couplings act like an automatic clutch by slipping at idling speeds and by holding to increase power as the engine speed increases. There is no mechanical connection between the engine and transmission; power is transmitted by oil.

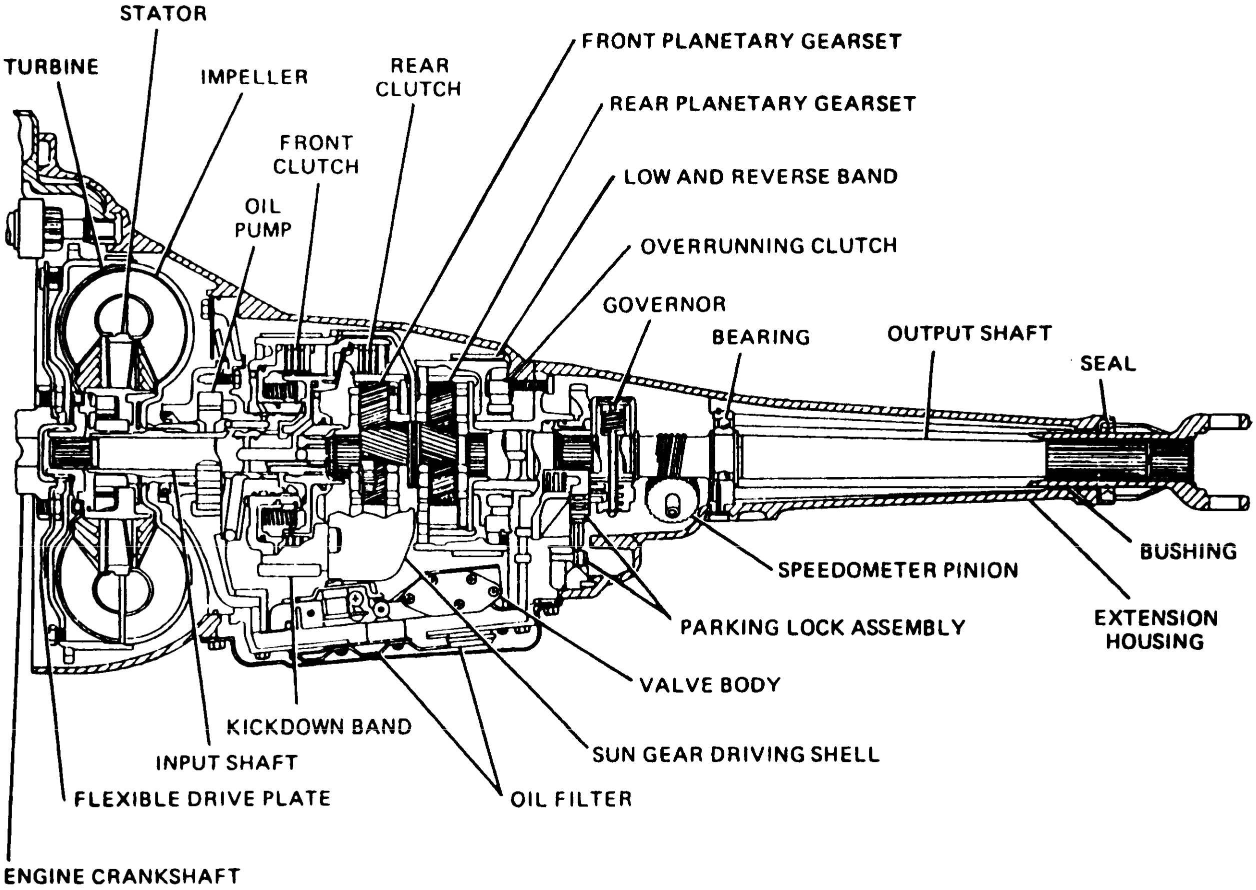

STATOR
TURBINE
IMPELLER
REAR CLUTCH
FRONT PLANETARY GEARSET
REAR PLANETARY GEARSET
FRONT CLUTCH
OIL PUMP
LOW AND REVERSE BAND
OVERRUNNING CLUTCH
GOVERNOR
BEARING
OUTPUT SHAFT
SEAL
BUSHING
SPEEDOMETER PINION
PARKING LOCK ASSEMBLY
EXTENSION HOUSING
VALVE BODY
KICKDOWN BAND
SUN GEAR DRIVING SHELL
INPUT SHAFT
FLEXIBLE DRIVE PLATE
OIL FILTER
ENGINE CRANKSHAFT

Figure 2-6.—Automatic transmission cross-sectional view.

The principle of fluid drive is shown in figure 2-7. As two fans face each other, the speed of rotation of one fan makes the other fan rotate. When the speed of one fan is changed from medium to low, power is lost at low speeds; but, if the fan speed increases from medium to high, the speed of the driven fan picks up.

Torque Converter

The torque converter is a form of and has replaced the fluid coupling. Most automatic transmissions used in automotive and construction equipment have torque converters.

The torque converter consists of three parts: the pump (driving member), the turbine (driven member), and the stator (reaction member), all with curved vanes. The stator is located between the load and the power source to act as a fulcrum and is secured to the torque converter housing. Figure 2-8 shows a cutaway view of a torque converter and the directional flow of oil. The pump throws out oil in the same direction in which the pump is turning. As the oil strikes the turbine blade, it forces the turbine to rotate, and the oil is directed toward the center of the turbine. Then the oil leaves the turbine and moves in a direction opposite to that of the pump. As the oil strikes the stator, it is redirected to flow in the same direction as the pump to add its force to that of the pump. Torque is multiplied by the velocity and direction given to the oil by the pump, plus the velocity and direction of the oil entering the pump from the stator.

Planetary Gears

Automatic transmissions use a system of planetary gears to enable the torque from the torque converter to be used efficiently.

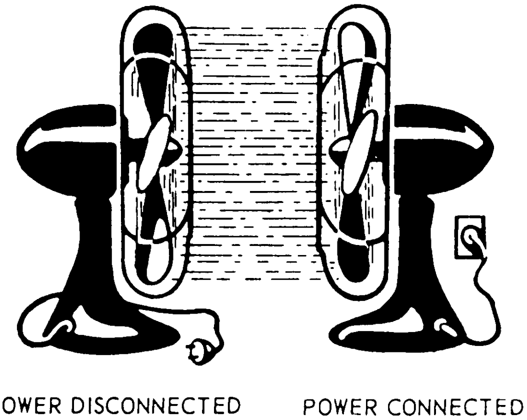


Figure 2-7.—Principle of fluid drive.

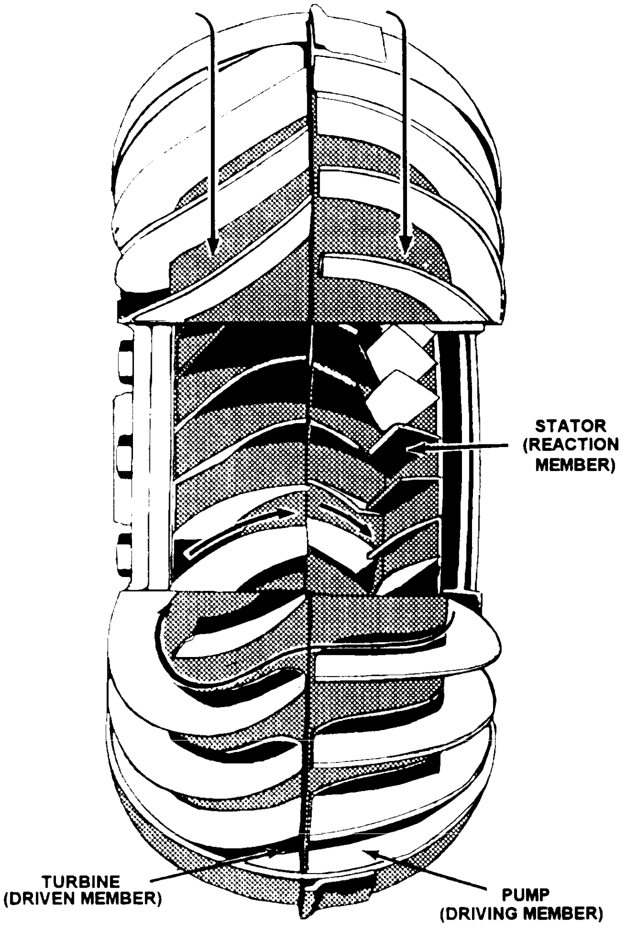


Figure 2-8.—Torque converter.

Planetary units are the heart of the automatic transmission. The four parts that make up the planetary gear system are as follows: the sun gear, the ring (or internal) gear, the planet pinions, and the planet carrier.

The sun gear is the center of the system. The term **planet** fits these pinions and gears, because they rotate around the sun gear, as shown in figure 2-9. The ring gear, or internal gear, is so-called because of its shape and internal teeth.

An advantage of the planetary gear system is that it is compact. Additionally, in the planetary system more teeth make contact to carry the load. The reason for this is that each gear of the planetary system usually meshes with at least two other gears. Because the gears are always in mesh, none of the teeth are damaged as a result of teeth clashing or a partial mesh. However, the major advantage of the planetary system is the ease of shifting gears. Planetary gears, set in automatic transmissions, are shifted without any special skill required by the operator.

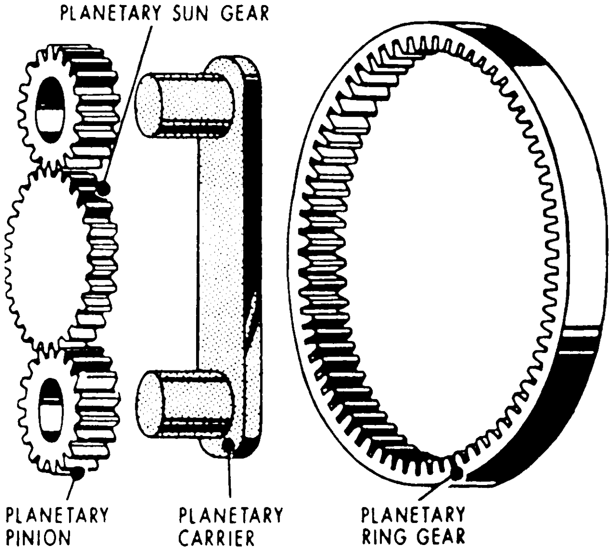


Figure 2-9.—Planetary gear system.

Power can be transmitted through the planetary gearset in various ways. A shaft from the engine may be connected to drive the sun gear. It may be connected to drive the planet carrier or the shaft may be connected to drive the ring gear. The propeller shaft may also be connected to anyone of these members; however, power can be transmitted in the planetary gear system only when (1) the engine is delivering power to one of the three members, (2) the propeller shaft is connected to one of the other members, and (3) the remaining member is held against rotation. All three conditions must be satisfied for power to be transmitted in the system. Automatic transmissions provide for holding a member through hydraulic servos and spring pressure.

Automatic Transmission Operation

Most automatic transmissions are basically the same. They combine a fluid torque converter with a planetary gearset and control the shifting of the planetary gear with an automatic hydraulic control system. The fluid torque converter is attached to the engine crankshaft and serves as the engine flywheel. This design means that when the engine runs, engine power flows into the converter and drives the converter output (turbine) shaft. There is no neutral in the torque converter. Neutral is provided in the planetary gearset by the release of bands and clutches.

The transmission automatically multiplies and transmits engine torque to the drive shaft as driving conditions demand. The speeds at which the coupling point and the gearshifts occur are controlled partially by the operator. The operator has only a partial control in the D-drive position, because the transmission in the D-drive position shifts the planetary gearset into the higher gears to prevent engine overspeeding regardless of throttle position.

The operation of automatic shift vehicles is quite simple; however, it is imperative that the professional operator learn to operate them smoothly and properly. In vehicles equipped with automatic transmissions, initial gear selection is controlled with a selector lever. When in drive (D or DR), shifting from drive to low (L) and returning to drive is controlled automatically by the engine speed.

Most vehicles have four or five of the following selector positions.

P-PARK POSITION.— On light vehicles, such as sedans and pickups, this position is used for locking the transmission so the vehicle cannot roll while parked. In some heavier vehicles, the park position does not lock the transmission. In vehicles with a park position, the engine should be started from the park position.

N-NEUTRAL POSITION.— Engines of vehicles not equipped with a P-park position are started from the N-neutral position. In this position, the engine is disengaged from the drive shaft of the vehicle.

D-DRIVE POSITION.—With the shift lever at D or DR, the vehicle moves forward as you depress the accelerator. After starting the engine in neutral or park position, step on the brake and change the selector to D or DR for forward movement. To avoid premature forward movement, keep pressure on the brake while in the drive position until you are ready to place the vehicle in motion. Without further operator action, the transmission automatically shifts to higher gears as speed increases.

L-LOW or POWER POSITION.— The transmission will not shift automatically to higher gear ratios when the lever is in the low position. The low position is used when negotiating steep grades and rough terrain or when the braking power of the engine is required. When low range is no longer needed, release the accelerator temporarily and move the shift lever to the drive position for normal gear progression. In the drive position, the low range is engaged automatically when engine speed is reduced. If the accelerator is suddenly fully depressed, the low range becomes engaged. (This procedure may be used to provide a sudden burst of speed for passing.) When a predetermined engine speed has been attained, the transmission automatically returns to driving range.

R-REVERSE POSITION.— Some shift levers must be raised slightly to be moved to the R or reverse position. Others may require the depressing of a button on the end of the lever before moving to R.

Become thoroughly familiar with the operator's manual, vehicle instruments, controls, and selector positions before operating a vehicle or piece of equipment. You may operate equipment that has the R-reverse position on the extreme right on some shift selectors, on the extreme left on others, and the intermediate position on others. From a force of habit, when you are in a different vehicle from the one you have been operating, you could move the selector lever to R, thinking you were moving it to D or L, and cause the vehicle to move in an entirely opposite direction than anticipated.

AUXILIARY TRANSMISSION

Auxiliary transmissions are mounted on the rear of the regular transmission to provide more gear ratios. Most auxiliary transmissions have only a L-low and a H-high (direct) range in a transfer assembly. The low range provides an extremely low gear ratio for hard pulls. At all other times, the high range should be used. Gears are shifted by a separate gearshift lever in the driver's cab (fig. 2-10).

Transfer Cases

Transfer cases are placed in the power trains of vehicles driven by all wheels (fig. 2-11). Their purpose is to provide the necessary offsets for additional propeller-shaft connections to drive the wheels.

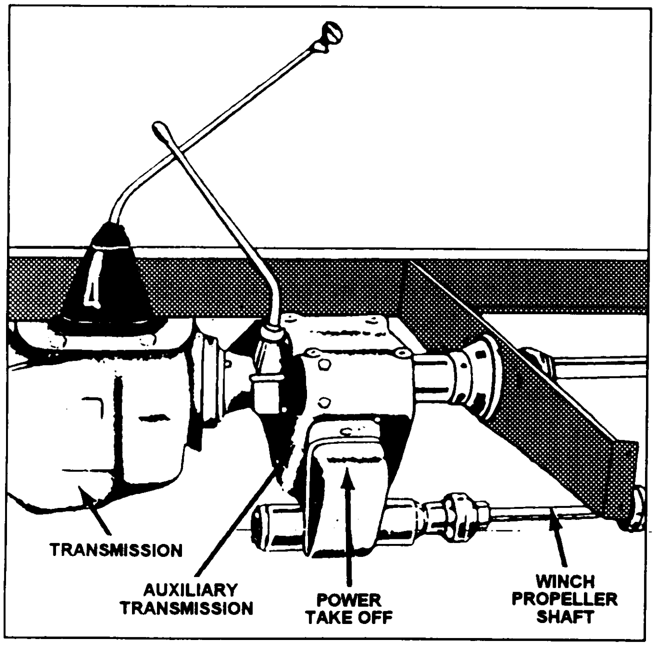


Figure 2-10.—Auxiliary transmission.

Transfer cases in heavier vehicles have two-speed positions and a declutching device for disconnecting the front driving wheels. Two-speed transfer cases also serve as auxiliary transmissions.

Transfer cases are quite complicated. When they have speed-changing gears, declutching devices, and attachments for three or more propeller shafts, they are even larger than the main transmission.

Some transfer cases have an overrunning sprag unit (or units) on the front output shaft. A sprag unit is a form of a overrunning clutch; power can be transmitted through it in one direction but not in the other. During normal operation, when both front and rear wheels turn at the same speed, only the rear wheels drive the vehicle.

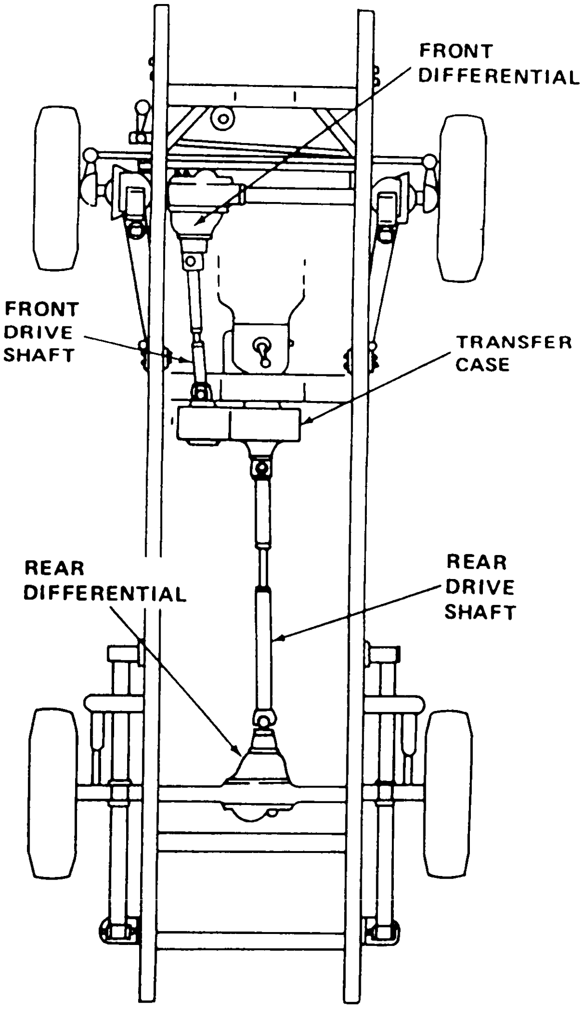


Figure 2-11.—Transfer case installed in a four-wheel drive truck.

However, if the rear wheels should lose traction and begin to slip, they tend to turn faster than the front wheels. When this occurs, the sprag unit automatically engages. This action allows the front wheels to also drive the vehicle. The sprag unit simply provides an automatic means of engaging the front wheels in drive for more traction.

Power Takeoffs

Power takeoffs, commonly known as the PTO, are attachments in the power train for power to drive auxiliary accessories. They are attached to the transmission, auxiliary transmission, or transfer case. A common type of PTO is the single-gear, single-speed type that is bolted to an opening provided in the side of the transmission case, as shown in figure 2-10. The sliding gear of the PTO meshes with the transmission countershaft gear. The operator can move a shifter shaft control lever to slide the gear in and out of mesh with the countershaft gear. The spring-loaded ball holds the shifter shaft in position.

On some vehicles, PTO units have gear arrangements that give two speeds forward and one in reverse. Several forward speeds and reverse gear arrangements are usually provided in PTO units used to operate winches and hoists.

PROPELLER SHAFT ASSEMBLIES

The propeller shaft assembly (fig. 2-12) consists of a propeller shaft, commonly know as the drive shaft, a slip joint, and two or more universal joints. This assembly provides a path through which power is transmitted from the transmission to the drive axle assemblies or auxiliary equipment. Vehicles, having a long wheel base, are equipped with a propeller shaft that extends from the transmission or transfer case to a center support bearing and a propeller shaft that extends from the center support bearing to the rear axle (fig. 2-13).

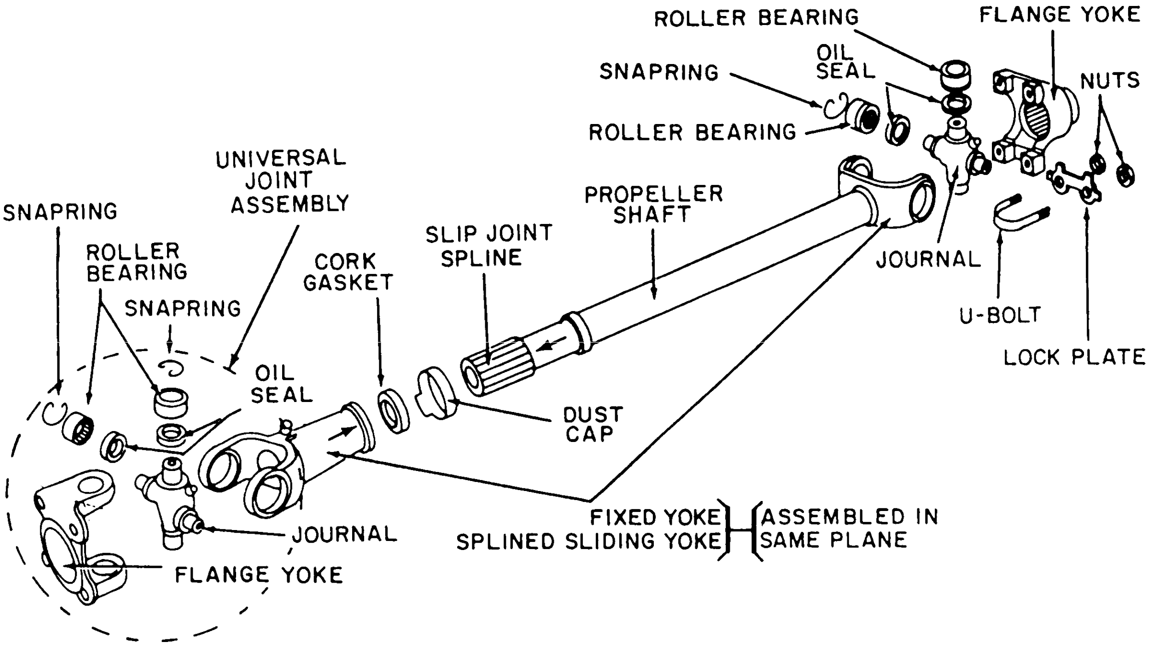

ROLLER BEARING
FLANGE YOKE
OIL SEAL
SNAPRING
NUTS
ROLLER BEARING
UNIVERSAL JOINT ASSEMBLY
PROPELLER SHAFT
SNAPRING
SLIP JOINT SPLINE
ROLLER BEARING
CORK GASKET
JOURNAL
SNAPRING
U-BOLT
LOCK PLATE
OIL SEAL
DUST CAP
FIXED YOKE
SPLINED SLIDING YOKE
ASSEMBLED IN SAME PLANE
JOURNAL
FLANGE YOKE

Figure 2-12.—Propeller shaft assembly.

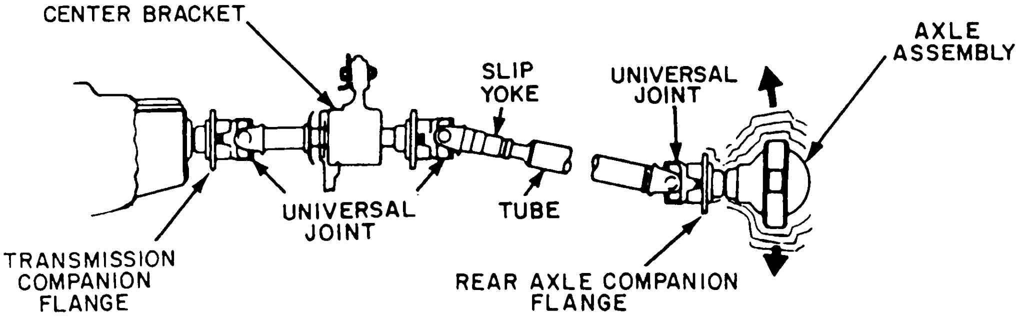

CENTER BRACKET
SLIP YOKE
UNIVERSAL JOINT
AXLE ASSEMBLY
UNIVERSAL JOINT
TUBE
TRANSMISSION COMPANION FLANGE
REAR AXLE COMPANION FLANGE

Figure 2-13.—Propeller shaft assembly with center support bearing.

Propeller shafts may be solid or tubular type and require little or no maintenance. Solid shafts are normally used where high shaft speeds are unnecessary. They are used extensively to power auxiliary equipment, such as winches and hydraulic pumps. The hollow shaft is used almost exclusively to transmit power to the axles on automotive vehicles. The hollow shaft, because it rotates at high speed, must be balanced to prevent vibration and premature bearing failure in the transmission and differential assemblies.

A slip joint at one end of the propeller shaft takes care of end play. The driving axle, attached to the springs, is free to move up and down, while the transmission is attached to the frame and cannot move. Any upward or downward movements of the axle causes the suspension springs to flex. This action shortens or lengthens the distance between the axle assembly and the transmission. The slip joint makes up for this changing vertical distance.

The type of slip joint normally used consists of a splined stub shaft, welded to the propeller shaft, that fits into a splined sleeve in the universal joint, as shown in figure 2-12.

UNIVERSAL JOINTS

A universal joint acts as a flexible coupling between two shafts and permits one shaft to drive another shaft that is at an angle to it. The universal joint is flexible in the sense that it permits power to be transmitted, while the angle of the shaft is being continually changed.

A conventional universal joint assembly is composed of three fundamental units: a journal (cross) and two yokes, as shown in figure 2-12. The two yokes are set at right angles to each other and are joined by the journal. This design permits each yoke to pivot on the journal, allowing the transmission of rotary motion from one yoke to the other. As a result, the universal joint can transmit power from the engine through the shaft to the drive axle, even when the engine is mounted in the frame at a higher level than the drive axle, as shown in figure 2-13.

Universal joints need little, if any, maintenance other than lubrication. Some universal joints have grease fittings and should be lubricated according to the manufacturer's specifications.

CENTER SUPPORT BEARINGS

When two or more propeller shafts are connected together in tandem, their alignment is maintained by a rubber-bushed center support bearing, secured to a cross member of the frame. A typical center support bearing assembly is shown in figure 2-14. The standard bearing is prelubricated and sealed and requires no further lubrication; however, some support bearings on heavy-duty vehicles have lubrication fittings. The first indication of support bearing failure is excessive chassis vibration at low speed caused by the bearing turning with the shaft in the rubber support.

FINAL DRIVES

A final drive transmits the power delivered from the propeller shaft to the drive wheels or to sprockets equipped on tracklaying equipment. Because it is located in the rear axle housing, the final drive is usually identified as a part of the rear axle assembly. The final drive consists of two gears, called the ring gear and pinion. These are beveled gears, and they may be worm, spiral, spur, or hypoid, as shown in figure 2-15.

The function of the final drive is to change by 90 degrees the direction of the power transmitted through the propeller shaft to the driving axles. It also provides a fixed reduction between the speed of the propeller shaft and the axles driving the wheels. In passenger

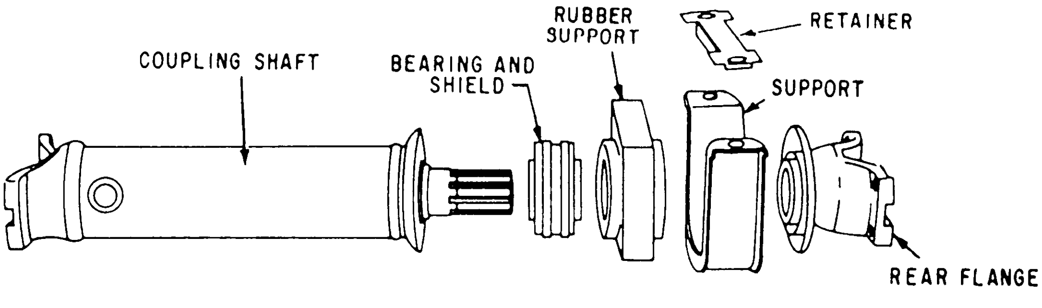


Figure 2-14.—Center support bearing.

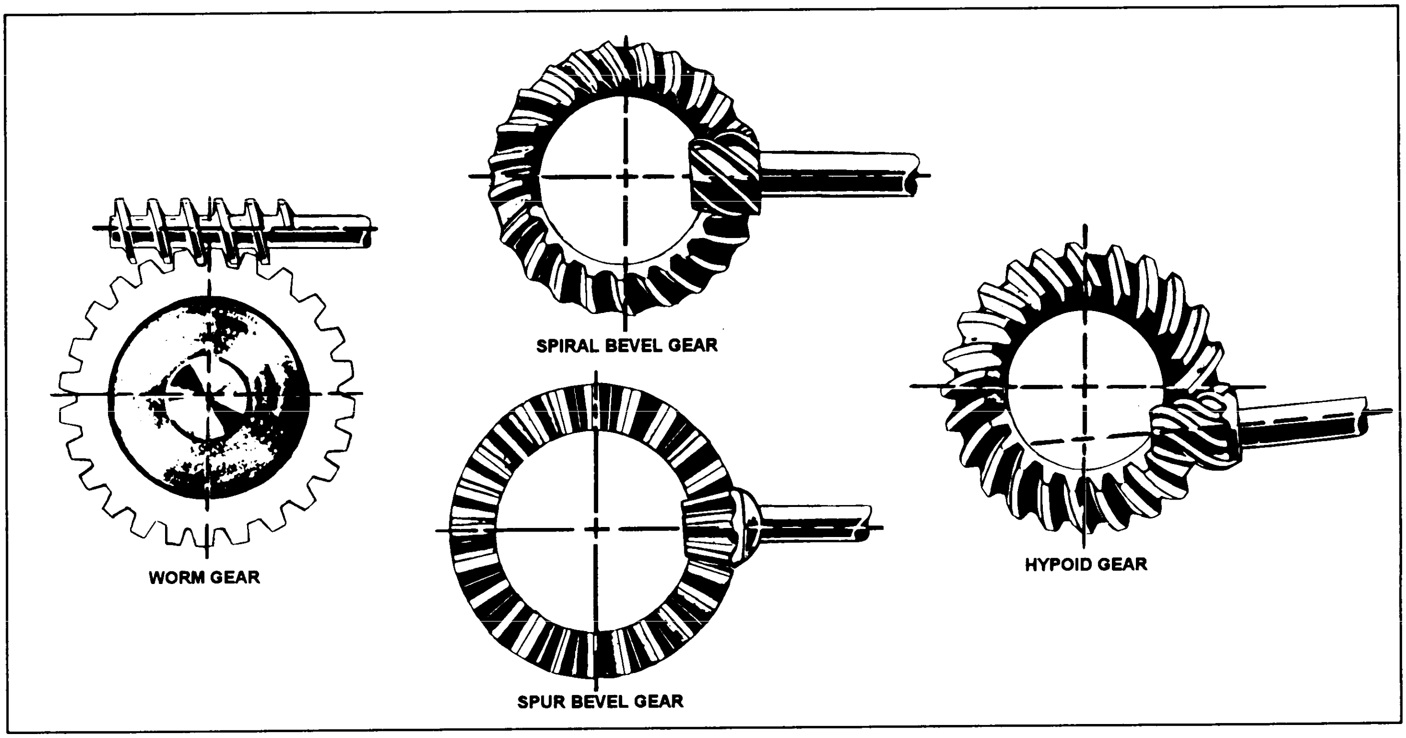


Figure 2-15.-Gears used in final drives.

cars, this reduction varies between 3 to 1 and 5 to 1. In trucks, it can vary from 5 to 1 to as much as 11 to 1.

The gear ratio of a final drive with bevel gears is frond by dividing the number of teeth on the driven or ring gear by the number of teeth on the pinion. In a worm gear final drive, the gear ratio is found by counting the number of revolutions of the worm gear for one revolution of the driven gear.

Most final drives are gear type. Hypoid differential gears permit a lower body design. They permit the bevel-driven pinion to be placed below the center of the ring gear, thereby lowering the propeller shaft, as shown in figure 2-15. Worm gears allow a larger speed reduction and are sometimes used on large trucks. Spiral bevel gears are similar to hypoid gears and are used in both passenger cars and trucks to replace spur gears that are too noisy.

DIFFERENTIALS

Another important unit in the power train is the differential, which is a type of final drive. As shown in figure 2-16, the differential is located between the axles and permits one axle shaft to turn at a different speed from that of the other. At the same time, the differential transmits power from the transmission/transfer case to both axle shafts. The variation in axle shaft speed is necessary when the vehicle turns a corner or travels over uneven ground. As a vehicle travels around a curve, the outer wheel must travel faster and further than the inner wheel. Without the differential, one rear wheel would be forced to skid when turns are made, resulting in excessive tire wear as well as making the vehicle more difficult to control.

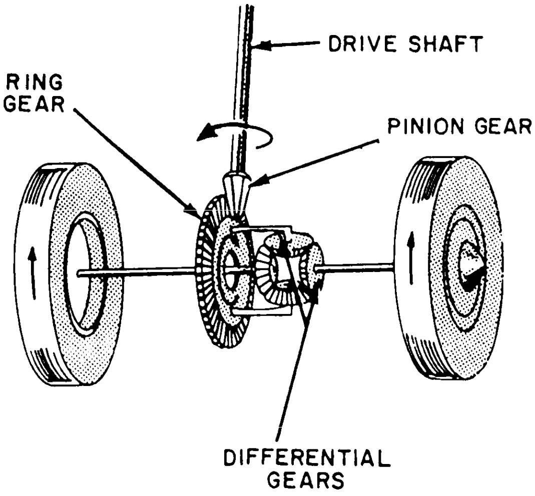


Figure 2-16.—Differential operation.

Some trucks have a differential lock to keep one wheel from spinning. This is a simple dog clutch, controlled manually or automatically. The differential lock locks one axle shaft to the differential case and bevel drive gear, forming a rigid connection between the two axle shafts that makes both wheels rotate at the same speed.

DRIVING AXLES

Axles are classified as either live or dead. The live axle is used to transmit power. The dead axle supports part of the vehicle weight but does not drive the wheels. The wheels rotate on the ends of the dead axle.

On rear wheel drive passenger cars, the front axle is a dead axle, and the rear axle is a live axle. In four-wheel drive vehicles, both front and rear axles are live axles, and in six-wheel drive vehicles, all three axles are live. Thee third axle, part of a bogie drive, is joined to the rearmost axle by a trunnion axle, as shown in figure 2-17. The trunnion axle is attached rigidly to the frame.

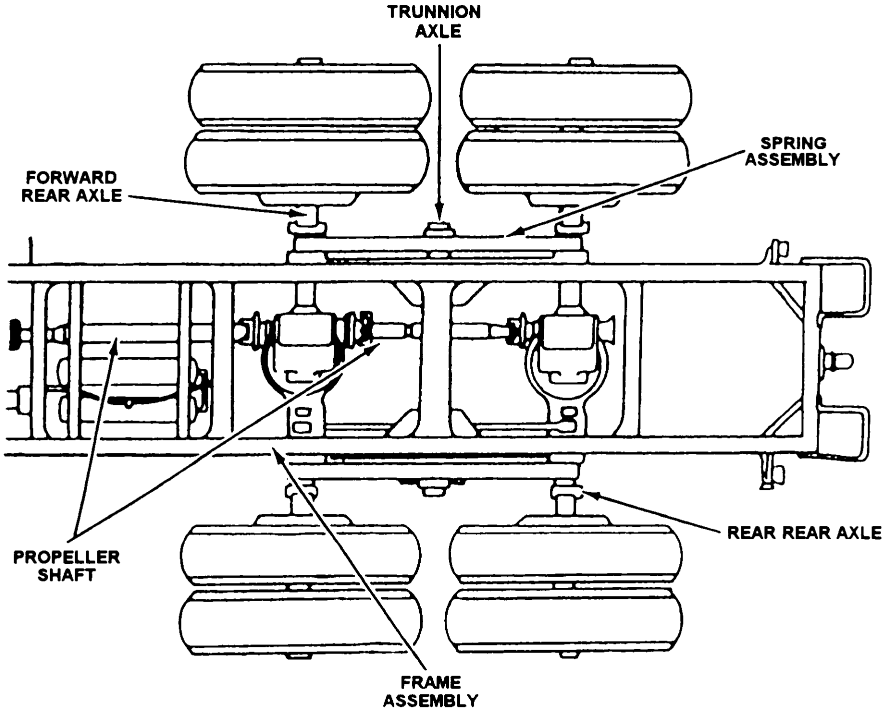

TRUNNION AXLE
SPRING ASSEMBLY
FORWARD REAR AXLE
REAR REAR AXLE
PROPELLER SHAFT
FRAME ASSEMBLY

Figure 2-17.—Bogie drive.

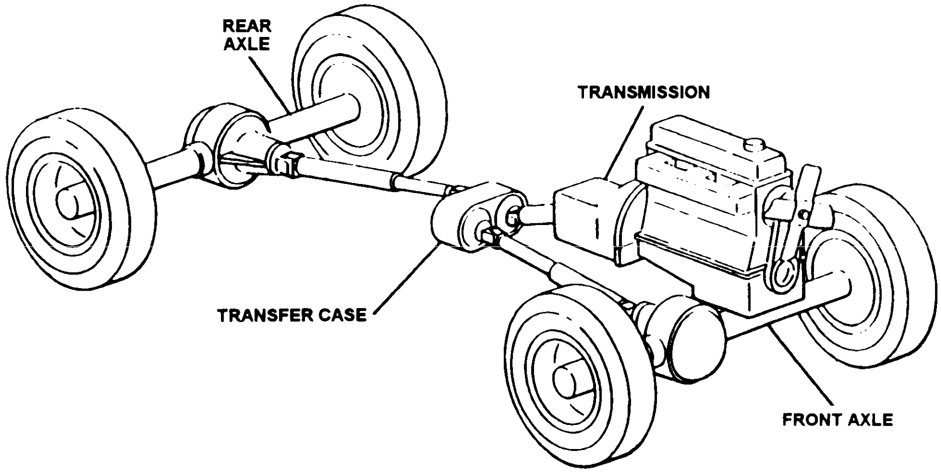

REAR AXLE
TRANSMISSION
TRANSFER CASE
FRONT AXLE

Figure 2-18.—Four-wheel drive transmission.

Its purpose is to help in distributing the load on the rear of the vehicle to the two live axles that it connects.

The three types of live axles that are used in automotive and construction equipment are as follows: semifloating, three-quarter floating, and full floating.

DRIVING WHEELS

Wheels attached to live axles are the driving wheels. Wheels attached to the outside of the driving wheels make up dual wheels. Dual wheels give more traction to the driving wheels and distribute the weight of the vehicle over more surface. Consider dual wheels as single wheels in describing vehicles.

The number of wheels is sometimes used to identify equipment; for example, a 4 by 2 could be a passenger car or a truck with four wheels, two of them driving. On a 4 by 4 (fig. 2-18), power is delivered to the transfer case where it is divided between the front and rear axle, allowing all four wheels to drive. A 6 by 4 truck with dual wheels in the rear is identified by six wheels, four of which drive. When a live axle is in front, the truck becomes a 6 by 6 (fig. 2-19), in which all six wheels drive.

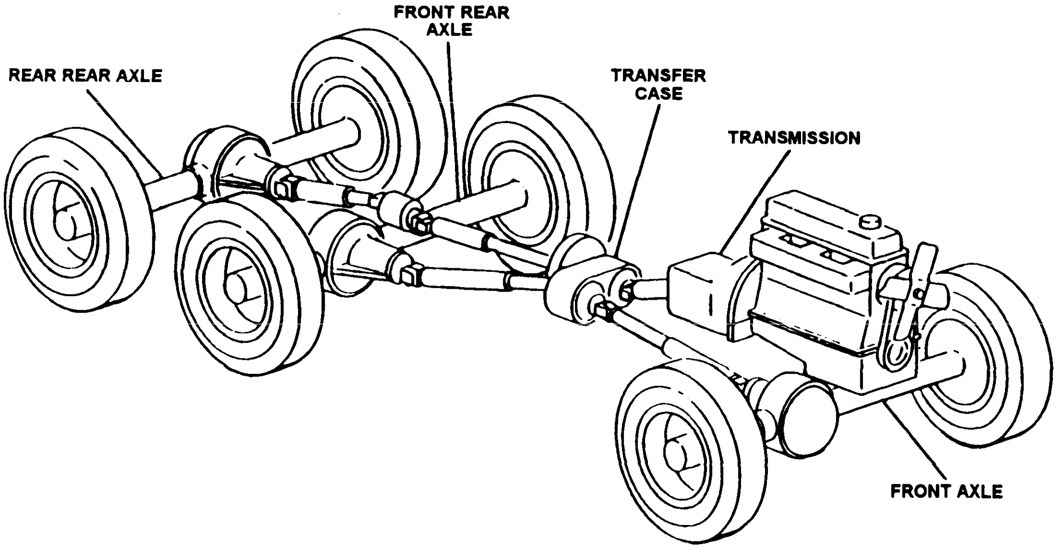


Figure 2-19.—Six-wheeled drive transmission.

CHAPTER 3

CHASSIS SYSTEMS

Chassis systems provides operators with a means of controlling the direction the equipment travels and allows travel over uneven terrain by controlling the amount of shock reaching the passengers or cargo. This chapter covers the basic principles of steering systems, suspension systems, tires, and brake systems.

STEERING SYSTEMS

Automotive steering mechanisms are classified as either manual or power. In both types, the arrangement and function of the linkage are similar. The main difference is that manual steering requires more effort for you to steer the vehicle. Some construction equipment has articulated steering which is powered by the equipment hydraulic system.

STEERING MECHANISMS

All steering mechanisms have the same basic parts (fig. 3-1). The steering linkage ties the front wheels together and connects them to the steering gear case at the lower end of the steering column which, in turn, connects the gear case to the steering wheel.

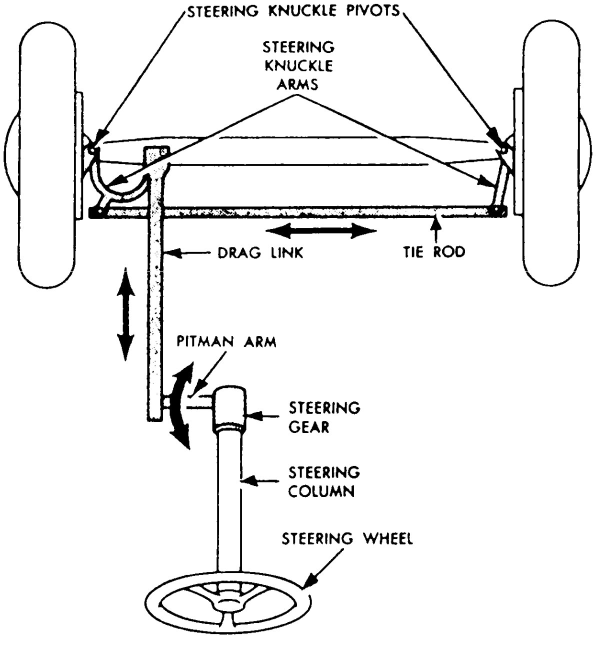


Figure 3-1.—Steering linkage assembly.

The arms and rods of the steering linkage have ball ends or ball-and-socket ends to provide a swivel connection between them. These joined ends have grease fittings, dust seals or boots, and many of them have end-play adjustment devices. These joints and devices must be adjusted and lubricated regularly.

The arms, rods, and joints of steering linkage in your equipment may be arranged differently from those shown in figure 3-1, but you will find them in the same general location in the front and underneath the vehicle.

The tie rod is usually behind the axle and keeps the front wheels in proper alignment. The tie rod is divided into two lengths and is connected to the steering gear near the center of the vehicle to provide for easier steering and maximum leverage.

The drag link between the steering arm and the pitman arm may be long or short, depending on the installation.

The pitman arm is splined to the shaft extending from the steering gear case. It moves in an arc with its position, depending on which direction the steering wheel is turned. The arm is vertical when the front wheels are straight ahead. Therefore, the length of the drag link is determined by the distance between the steering arm and the vertical position of the pitman arm. Unlike the tie rods, the length of the drag link is fixed.

Part of your prestart and operator maintenance responsibilities is to check and service the steering linkage lubrication. One example is the connecting joints between the links that contain bushings. Additionally, when a vehicle is equipped with manually operated steering, check the steering gear housing for lubrication, and, if needed, add the recommended manufacturer's gear lubricant. If the vehicle is equipped with power steering, check the belt tension because improper tension can cause low oil pressure and hard steering. Check the fluid level. If the fluid level is low, add fluid to bring it up to the recommended level and only use the recommended power steering fluid. Also, if the level is low, there may be a leak; therefore, check hose and power steering connections for signs of leaks.

The connections may only need tightening to eliminate leaks; however, leakage may occur at various points in the power steering unit if the seals are defective. Document conditions and report them to the maintenance shop for replacement of any defective seal.

The types of steering troubles that develop in vehicle operations that should be documented and turned in for repair are as follows:

- Excessive play in the steering system
- Hard steering
- Vehicle wanders
- Vehicle pulls to one side when braking
- Front-wheel shimmy
- Front-wheel tramps (high-speed shimmy)
- Steering kickback
- Tires squeal on turns

Improper tire wear

- Unusual noises

These problems must be documented and turned in for repairs.

POWER STEERING

Power steering (fig. 3-2) adds the following components to the steering assembly: a hydraulic pump, a fluid reservoir, hoses, lines, and a steering assist unit whether mounted on the linkage or incorporated in the steering gear assembly.

ARTICULATED STEERING

Hydraulic power is used to turn a whole section of a machine on a vertical hinge. This design is called articulated steering and it is controlled by a steering wheel, a hydraulic control valve, and hydraulic cylinders. (See fig. 3-3.) The pivot is midway in the vehicle, so both parts share equally in the pivoting. This action produces the effect of four-wheel coordinated steering, such as the front-and-rear wheels run in each others tracks, backward and forward.

FRONT-AND-REAR STEERING

Wheeled equipment may be designed to steer by angling the front wheels, the rear wheels, and or both the front-and-rear wheels (fig. 3-4). Front-wheel steering is the standard method. The vehicle follows the

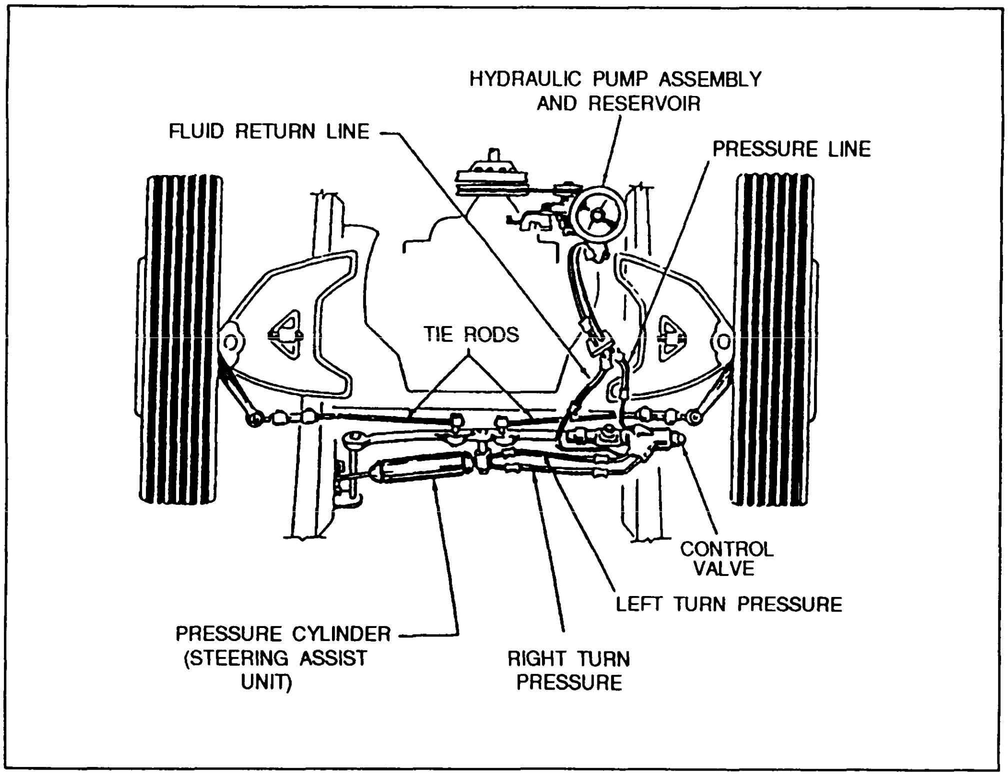


Figure 3-2.-Power steering linkage assembly.

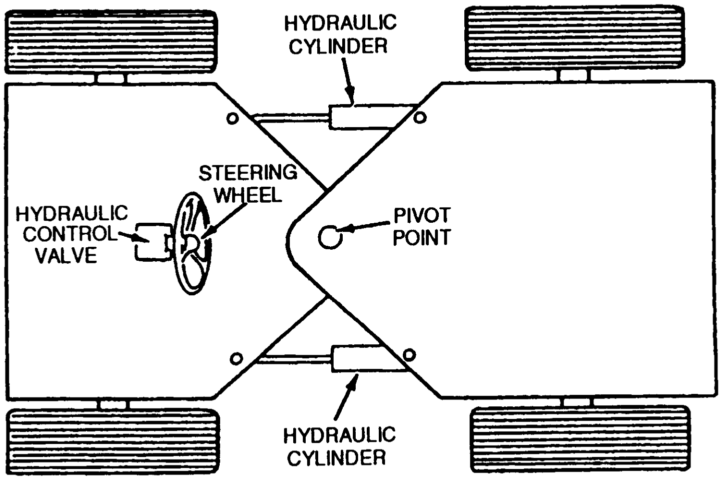

HYDRAULIC CYLINDER
STEERING WHEEL
HYDRAULIC CONTROL VALVE
PIVOT POINT
HYDRAULIC CYLINDER

Figure 3-3.-Articulated steering assembly.

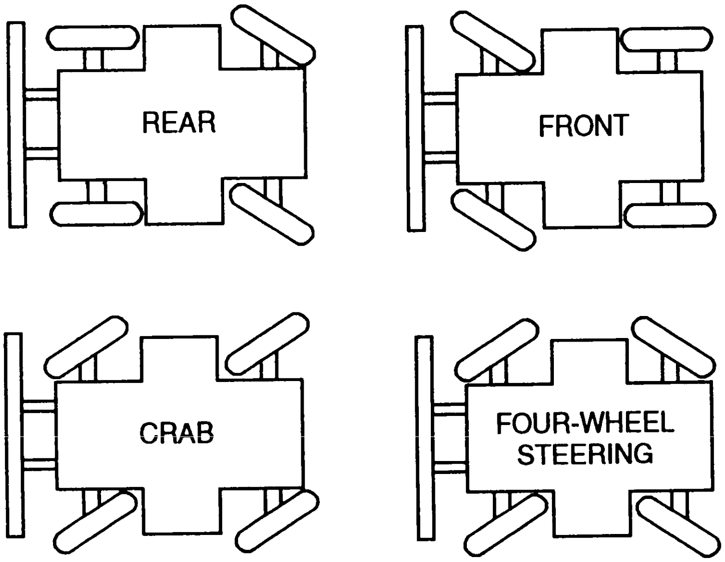

REAR
FRONT
CRAB
FOUR-WHEEL STEERING

Figure 3-4.-Front-and-rear steering.

angling of the wheels and the rear wheels do not go outside the path of the front ones, but trail inside.

Rear-wheel steering swings the rear wheels outside of the front-wheel tracks. The principal advantage is greater effectiveness in handling off-center loads at either the front or rear and preventing path down a sideslope. This type of steering is used with front-end loaders, as it keeps the weight of the machine squarely behind the bucket on turns and keeps the front tires tracking in the rear while backing away from banks and dump trucks. In new equipment, this design has been replaced by articulation.

In four-wheel steering, the front wheels are turned one way and the rear wheels are turned to the same angle in the opposite direction. The trailing wheel always moves in the same track as the leading wheel whether the equipment is moving forward or backward. This design lessens rolling resistance in soft ground, because one set of tires prepares a path for the other set. Additionally, this design provides maximum control of the direction of the load. Also, it enables the equipment to be held on a straight course and permits short turns in proportion to the maximum angle of the wheels.

In crab steering, both sets of wheels are turned in the same direction. If both sets of wheels are turned at the same angle, the machine moves in a straight line at an angle to its centerline. Results can be obtained from either four-wheel steering or crab steering by using different turning angles on independently controlled front-and-rear wheels.

SUSPENSION SYSTEMS

A suspension system anchors and suspends the wheels or tracks from the frame with springs, as shown in figure 3-5. It supports the weight and allows the vehicle to be driven under varying loads and speed conditions over bumpy roads and rough terrain without great risk of damage.

Although suspension systems are a part of your prestart and operator maintenance responsibilities, they usually do not need to be adjusted or replaced for many miles. The spring assemblies of the suspension system should be checked regularly to ensure that shackles are tight and that bushings within the shackles are not overworn or frozen tight. Occasionally, spraying lubricating oil on the spring leaves helps to prevent squeaking at the ends of the spring leaves. Following the lubrication chart for a particular vehicle, check and lubricate the front suspension system, including linkages, kingpins, and ball joints. During your checks you may find shock absorber bushings worn. If so, document it and turn it in so the problem can be looked at. The Construction Mechanic (CM) inspector may decide the shock absorbers should be replaced.

Some symptoms of suspension troubles in vehicle operation that should be documented and turned in for repair are as follows:

- Hard steering
- Vehicle wanders
- Vehicle pulls to one side during normal driving
- Front-wheel shimmy
- Front-wheel tramps (high-speed shimmy)
- Steering kickback

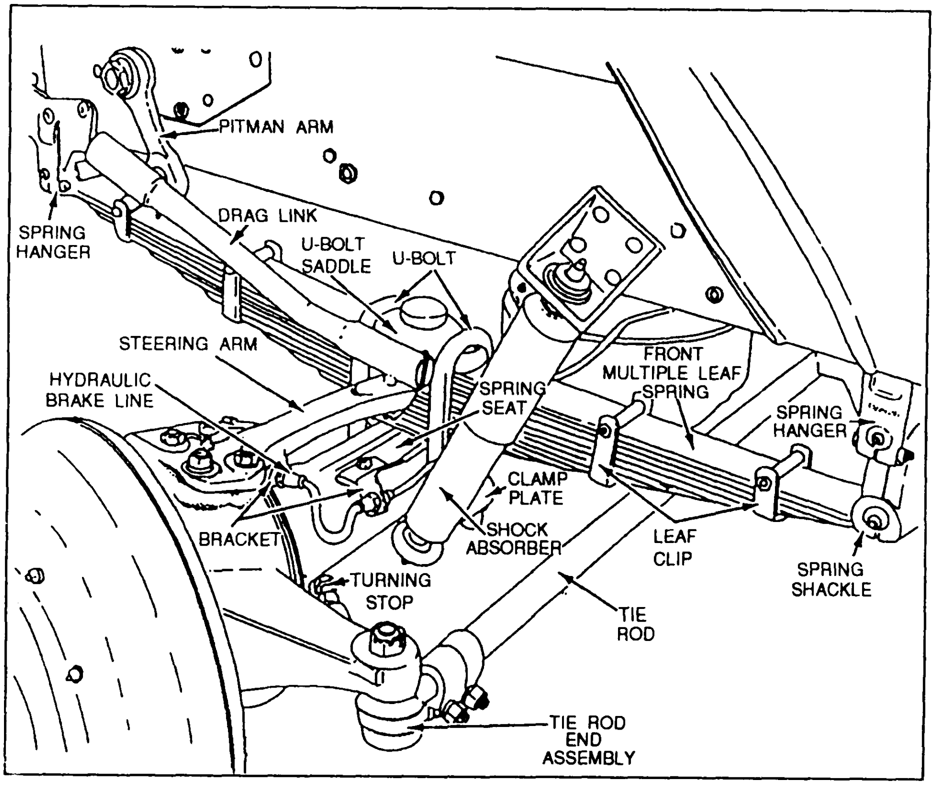

PITMAN ARM
SPRING HANGER
DRAG LINK
U-BOLT SADDLE
U-BOLT
STEERING ARM
HYDRAULIC BRAKE LINE
SPRING SEAT
FRONT MULTIPLE LEAF SPRING
SPRING HANGER
CLAMP PLATE
SHOCK ABSORBER
LEAF CLIP
SPRING SHACKLE
BRACKET
TURNING STOP
TIE ROD
TIE ROD END ASSEMBLY

Figure 3-5.—Front axle suspension system.

- Hard or rough ride
- Sway on turns
- Spring breakage
- Sagging springs
- Noises

The components of a suspension system are the springs and shock absorbers. Some suspension systems also have torsion bars.

SPRINGS

The springs support the frame and the body of the vehicle as well as the load the vehicle carries. They allow the wheels to withstand the shocks of uneven road surfaces and provide a flexible connection between the wheels and the body. The best spring absorbs road shock rapidly and returns to its normal position slowly. Extremely flexible or soft springs allow too much movement of the vehicle superstructure, while stiff, hard springs do not allow enough movement.

The springs do not support the weight of the wheels, rims, tires, and axles. These parts make up the "unsprung weight" of the vehicle. The unsprung weight decreases the action of the springs and is, therefore, kept to a minimum to permit the springs to support the vehicle frame and load.

Multiple Leaf Springs

The multiple leaf spring is part of the front axle suspension system, as shown in figure 3-5. It consists of a number of steel strips or leaves of different lengths fastened together by a bolt through the center. Each end of the largest or master leaf is rolled into an eye which serves as a means of attaching the spring to the spring hanger and spring shackle. Leaf rebound clips surround the leaves at two or more intervals along the spring to keep them from separating on the rebound after the spring has been depressed. The clips allow the spring leaves to slide but prevent them from separating and throwing the entire rebound stress on the master leaf. The spring thus acts as a flexible beam. Leaf springs may be suspended lengthwise (parallel to the frame) or crosswise.

When a leaf spring is compressed, it must straighten out or break; therefore, spring shackles are required at one or both ends of the spring. Spring shackles provide a swinging support and allow the spring to straighten out when compressed. One shackle is used in either the front or rear support of springs installed lengthwise. Two shackles support springs installed crosswise. Figure 3-6 shows how a leaf spring is attached to a frame by a spring shackle.

The most common types of spring shackles are the link shackle and the U-shackle. Heavy vehicles have link shackles. The U-type is more common on passenger cars and light trucks.

On some wheeled tractors, link shackles support a transverse spring on the dead front axle. Most wheeled tractors do not even have springs, and all load cushioning is through large, low-pressure tires.

Track tractors have one large leaf spring (fig. 3-7) supported without spring shackles. Fastened to the engine support, it rests on the frame supporting the tracks and rollers. Brackets on the track frames keep the spring from shifting.

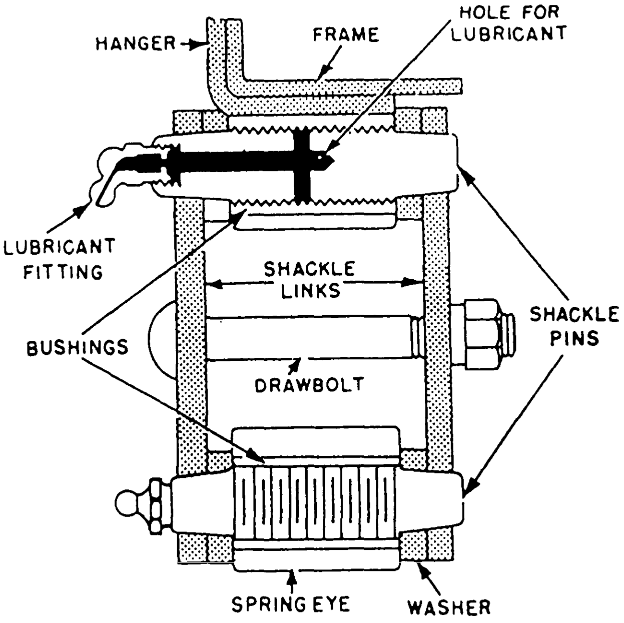


Figure 3-6.-Cross section of a shackle link.

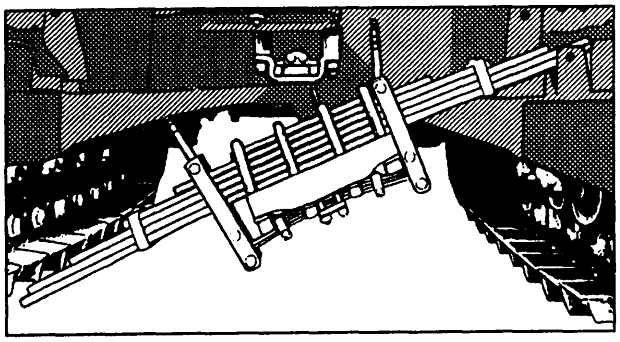


Figure 3-7.-Partially removed tracklayer spring.

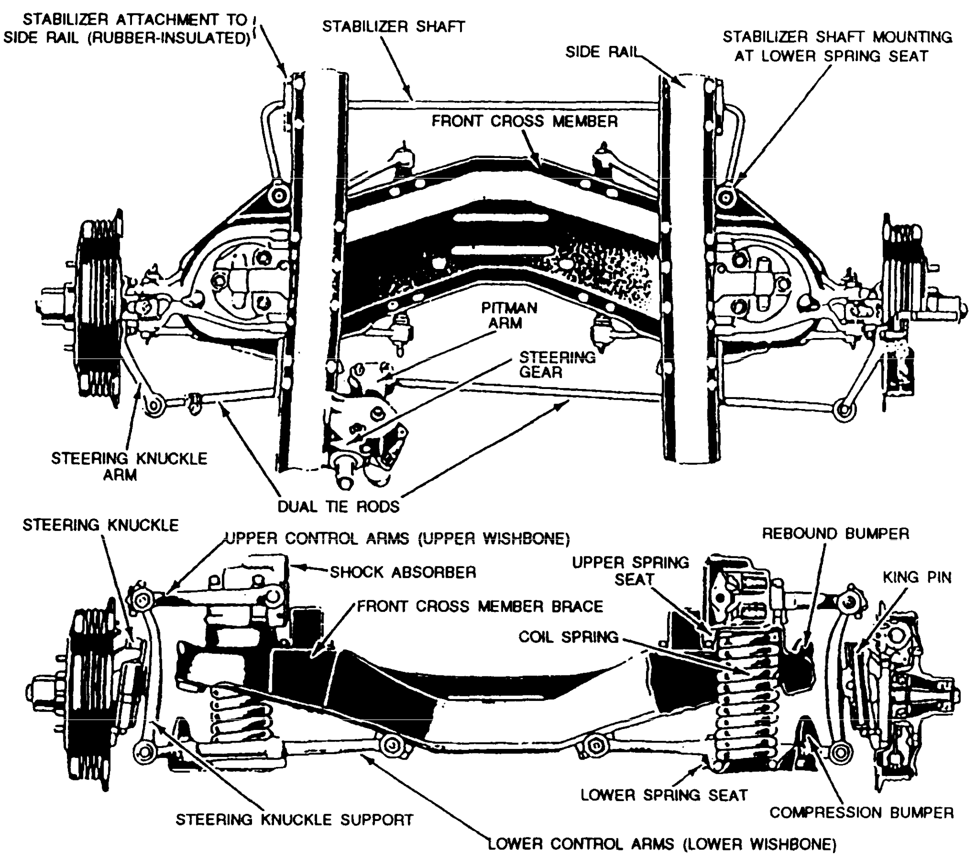

STABILIZER ATTACHMENT TO SIDE RAIL (RUBBER-INSULATED)
STABILIZER SHAFT
SIDE RAIL
STABILIZER SHAFT MOUNTING AT LOWER SPRING SEAT
FRONT CROSS MEMBER
PITMAN ARM
STEERING GEAR
STEERING KNUCKLE ARM
DUAL TIE RODS
STEERING KNUCKLE
UPPER CONTROL ARMS (UPPER WISHBONE)
REBOUND BUMPER
SHOCK ABSORBER
UPPER SPRING SEAT
KING PIN
FRONT CROSS MEMBER BRACE
COIL SPRING
LOWER SPRING SEAT
COMPRESSION BUMPER
STEERING KNUCKLE SUPPORT
LOWER CONTROL ARMS (LOWER WISHBONE)

Figure 3-8.-Coil spring suspension.

Some vehicles are equipped with leaf springs at the rear wheels only; others are so equipped both front and rear.

Coil Springs

Coil springs (fig. 3-8) are generally used on independent suspension systems. They provide a smooth ride. Their use has normally been limited to passenger vehicles. Recently, however, they have been used on trucks.

In figure 3-9, you can see how a coil spring is mounted. The spring seat and hanger, shaped to fit the coil ends, hold the spring in place. Spacers of rubberized material are placed at each end of the coil to prevent squeaking. The rubber bumper, mounted in the spring supporting member, prevents metal-to-metal contact when the spring is compressed. Most vehicles are equipped with coil springs at the two front wheels, while some others have them at both front and rear.

SHOCK ABSORBERS

Springs alone cannot meet the requirements for a light vehicle suspension system. A stiff spring gives a hard ride, because it does not flex and rebound when the vehicle passes over a bump. On the other hand, too flexible a spring rebounds too much, and the vehicle rides rough. For these reasons, shock absorbers are needed to smooth the ride of the vehicle. They do so by keeping the vehicle from jolting too much, by balancing spring stiffness and flexibility, and by allowing the springs to return to rest after they are compressed. Although single-acting shock absorbers check only spring rebound, double-acting shock absorbers check spring compression and spring rebound to permit the use of the more flexible springs.

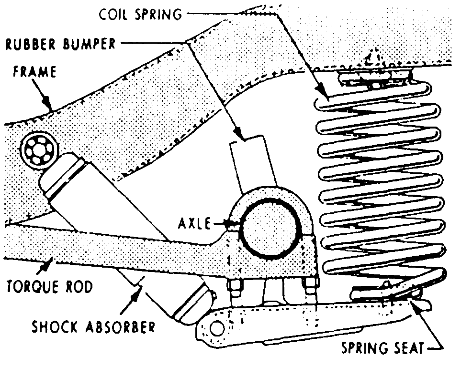

COIL SPRING
RUBBER BUMPER
FRAME
AXLE
TORQUE ROD
SHOCK ABSORBER
SPRING SEAT

Figure 3-9.-Coil spring mounting.

FRONT AXLE SUSPENSION

Most passenger car front wheels are individually supported with independent suspension systems. The ones you are likely to see are the coil spring and the torsion bar suspension systems used with independent front axles and shock absorbers.

REAR AXLE SUSPENSION

Driving wheels are mounted on a live-driving axle suspended by springs attached to the axle housing. Leaf springs generally suspend live axles using the Hotchkiss drive, as shown in figure 3-10. Coil springs are used on a number of passenger cars with independent suspension.

TIRES

Because tires are expensive, they require proper care and maintenance. While natural wear and tear affects tire life, premature tire failure can be caused by abuse and neglect. Proper maintenance of tires results in better performance and longer service and prevents a hazardous tire failure that can cause loss of life and equipment.

TIRE INSPECTION

Tires are cut by sharp objects, bruised by bad roads and stones, and injured by road shocks in general. To drive with a seriously damaged tire is dangerous, because it may blow out and cause the driver to lose control of the vehicle.

Carefully inspect your vehicle tires during prestart and post operations. Remove glass, nails, stones, and other foreign materials embedded in tires. Tires give longer mileage and safer driving when damages are repaired immediately.

Inflation

Correct air pressure is the basis for reliable tire performance. Tires are designed to operate at specified air pressures for given loads and inflated to the prescribed air pressure for your driving condition. When checking air pressure, use an accurate gauge and check the valve cores for leaks.

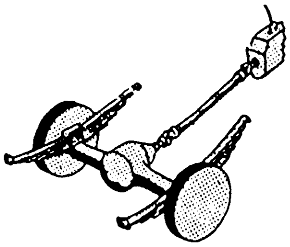


Figure 3-10.—Hotchkiss drive.

NOTE: Reduce the tire pressure when driving in soft sand and over dunes. This increases the amount of tire surface in contact with the sand to provide better flotation (support). However, never reduce the tire pressure so much that the tire slips on the rim. On some equipment, the air pressure for normal conditions and off-road conditions is listed on a data plate on the dashboard or in the operator's manual. When operating with reduced tire pressure, drive at low speed. Inflate the tires to normal pressure as soon as the situation permits.

PROPERLY INFLATED.— A properly inflated tire, as shown in figure 3-11, view A, shows proper contact with the road.

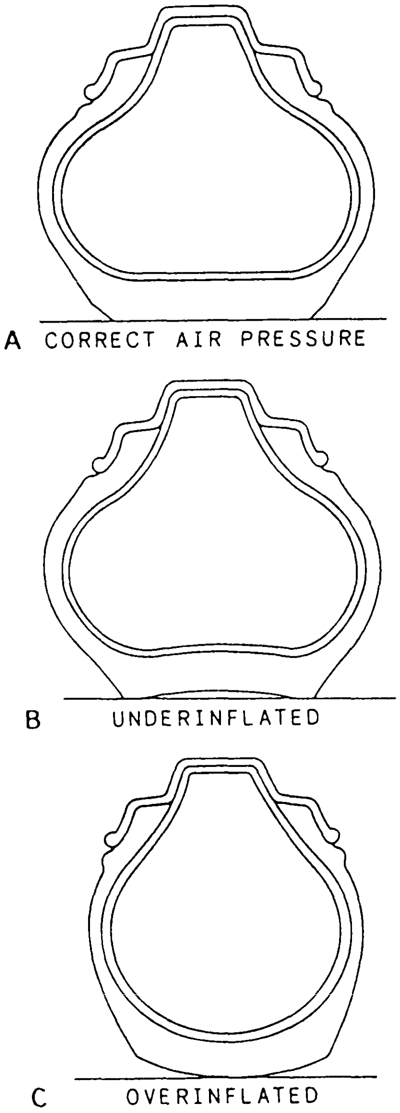


Figure 3-11.—Proper and improper tire inflation.

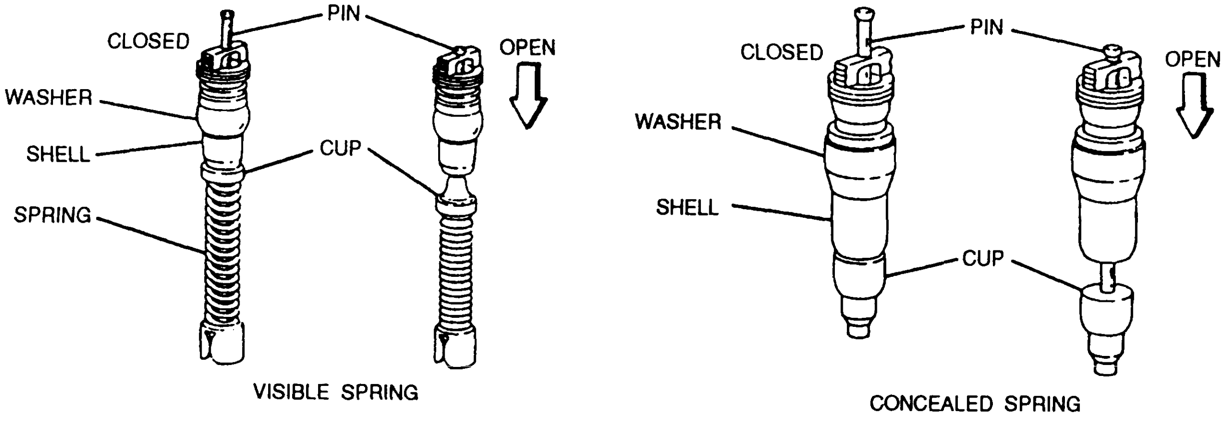


Figure 3-12.—Valve cores.

UNDERINFLATED.— An underinflated tire is shown in figure 3-11, view B. This tire does not contain enough air for its size and the load it must carry. It flexes excessively in all directions and gets hot. In time, the heat weakens the cords in the tire, and it blows out. Underinflation also causes tread edges to scuff the road that puts uneven wear on the tread and shortens tire life. Never run a tire flat, or nearly flat, unless the tactical situation in combat requires it. When run flat for even a short distance or almost flat for a long distance, the tire may be ruined beyond repair.

OVERINFLATED.— An overinflated tire is shown in figure 3-11, view C. Too much air pressure also causes tire failure. Excessive pressure prevents the tire from flexing enough and causes it to be constantly subjected to hard jolts. When an overinflated tire hits a stone or rut, the cords may snap and cause a break in the cord body. The center of the tread wears more rapidly and does not permit equal wear across the entire tread. Hard riding from too much air pressure also increases wear and tear on the vehicle.

Valves

For speed and convenience during inflation, valve stems should be readily accessible. They should be properly centered in the valve holes and slots to prevent scraping against the brake drums. They should be placed so the valves extend through the wheels. Valves on the inside duals should point away from the vehicle, and the valves on the outside duals should point toward the vehicle. On dual wheels, the valve of the outside dual is placed 180 degrees from the inside valve for speed and convenience in checking pressures and inflation. With this arrangement, the locations of the valves are always known even when you are checking them in the dark. Spare tires should be mounted so that the valve is accessible for checking and inflating.

VALVE CORES.— The valve core (fig. 3-12) is that part of the valve that is screwed into the valve stem and permits air, under pressure, to enter, but prevents it from escaping. Two types of valve cores and two sizes of each type are in use today. The two types are the visible spring type and the concealed spring type. The two types are interchangeable. Two sizes are provided for the standard bore and the large bore valve stems. The core shell has a rubber washer that provides an airtight seal against the tapered seat inside the stem. Directly below the shell is a cup that contains a rubber seat, which, in the closed position, is forced against the bottom of the shell, forming an airtight seal. The pin on top of the valve core, when pushed down, forces the cup away from the shell, permitting air to flow.

VALVE CAPS.— The valve cap (fig. 3-13) is also a component part of the valve and is screwed onto the end of the stem, providing a second airtight seal. The cap also protects the threads on the end of the stem and

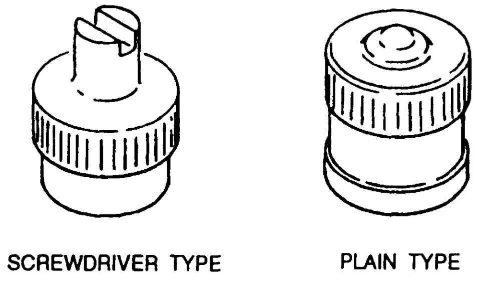


Figure 3-13.—Valve caps.

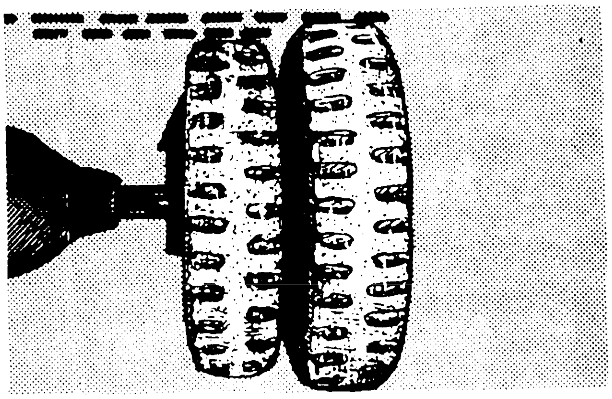


Figure 3-14.—Mismatched tires

keeps dirt and moisture out of the valve body. The screwdriver cap has a forked tip that may be used to install or remove the valve core. The plain cap generally is used on rubber-covered valves and has a skirt that contacts the rubber covering on the valve stem. Both caps are interchangeable with each other. Part of your prestart operation is making sure that all valve stems have valve caps.

Mismatching

For longer tire life and more efficient performance, dual tires and tires on all-wheel drive vehicles must be of the same size, tread design, and tread wear. Improperly matched tires cause rapid uneven wear and can also cause transfer case and differential failures.

Accurate matching of tires is necessary, because tires on axle-drive vehicles rotate at the same speed when all axles are engaged. Dual wheels turn at the same speed, because they are locked together which means that tires on all driving wheels must be of the same circumference and diameter. When one tire of a pair of duals is worn considerably more than the other, the tire cannot carry its proper share of the load and will scrub the road (fig. 3-14). The result is uneven and rapid wear on both tires and/or tire failure.

Tires should be used in sets. Mixing different types (bias ply, fiber glass belted, radial ply) must be avoided. Snow tires should be of the same size and type of construction as the front tires. Radial-ply tires should always be used in sets.

NOTE: Under no circumstances should radial-ply tires be mixed with bias-ply tires, together or on the same axle.

The problems encountered when mixing tires on a vehicle are loss of steering control, inadequate vehicle handling, and potential mechanical damage. These problems vary depending on the stability of the tires used, differences in dimensions, differences in air pressure, and other operating conditions.

RADIAL-PLY TIRES.— Radial-ply tires (fig. 3-15) are constructed with casing plies perpendicular to the tread direction, with several layers of tread-reinforcing plies (steel or fabric) just under the tread area. This construction permits flexing of the tire with a minimum of tread distortion, better traction, and a softer ride.

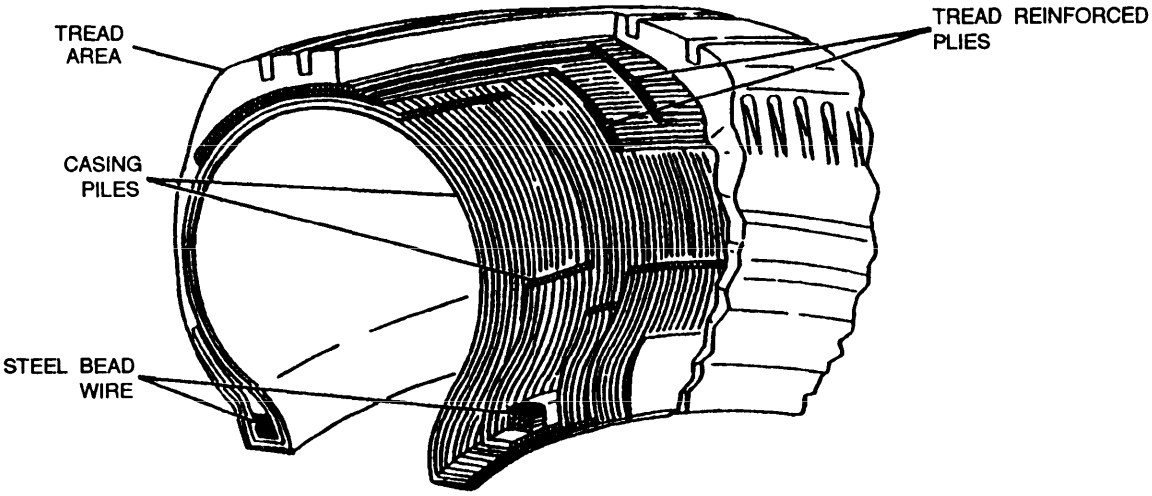


Figure 3-15.—Radial-ply tire construction.

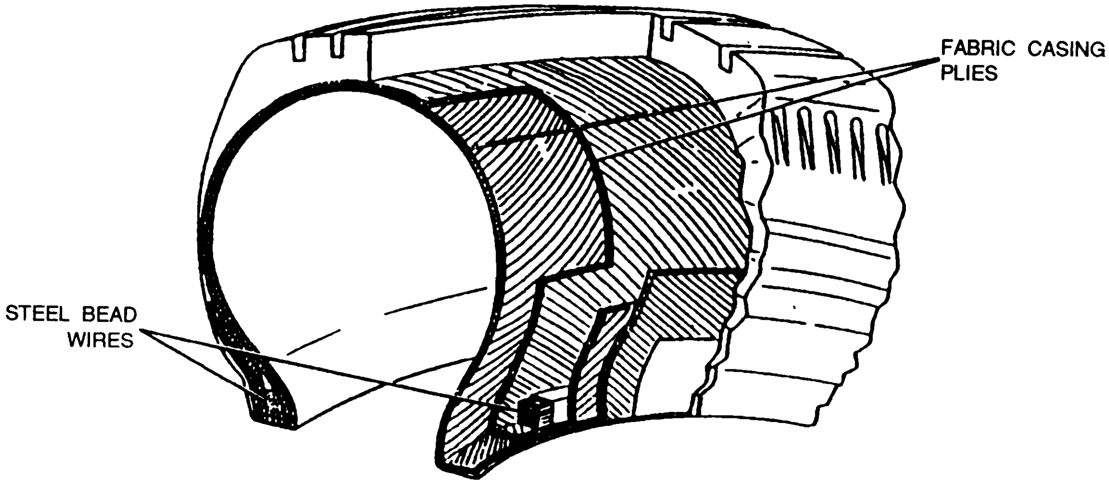

FABRIC CASING PLIES
STEEL BEAD WIRES

Figure 3-16.-Bias-ply tire construction.

BIAS-PLY TIRES.— Bias-ply tires (fig. 3-16) are constructed of rayon, nylon, or polyester casing plies in a crisscross pattern wrapped around steel bead wires. These bead wires prevent the tire from opening up and separating from the rim at high speeds. The casing plies give the tire its shape.

Mechanical Irregularities

Uneven tire wear is often caused by mechanical irregularities on your piece of equipment. During your prestart and post operations, inspect your tires for wear, as shown in figure 3-17. These conditions can be caused

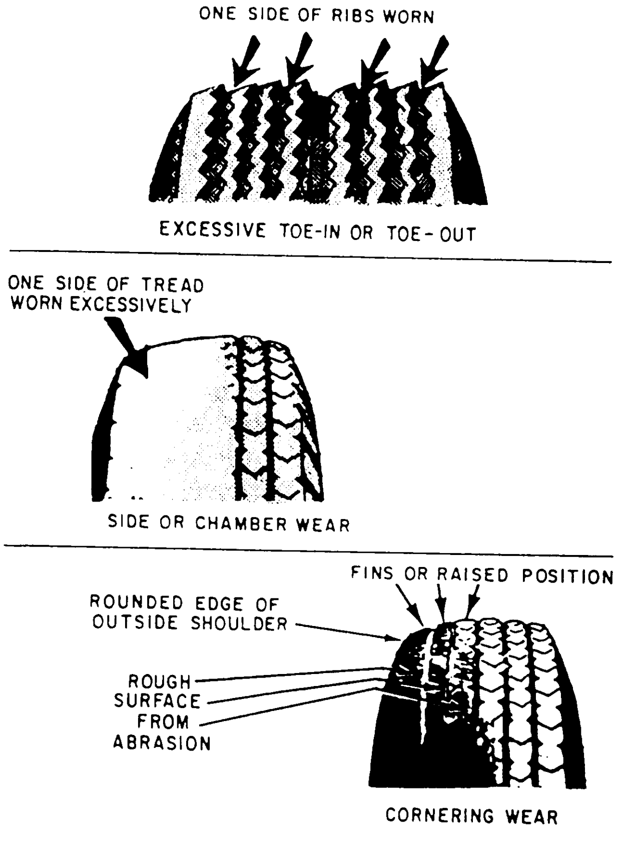

ONE SIDE OF RIBS WORN
EXCESSIVE TOE-IN OR TOE-OUT
ONE SIDE OF TREAD WORN EXCESSIVELY
SIDE OR CHAMBER WEAR
FINS OR RAISED POSITION
ROUNDED EDGE OF OUTSIDE SHOULDER
ROUGH SURFACE FROM ABRASION
CORNERING WEAR

Figure 3-17.-Results of mechanical irregularities.

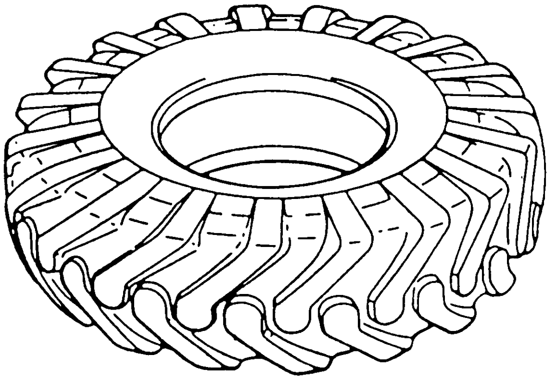


Figure 3-18.—Directional mud and snow tread.

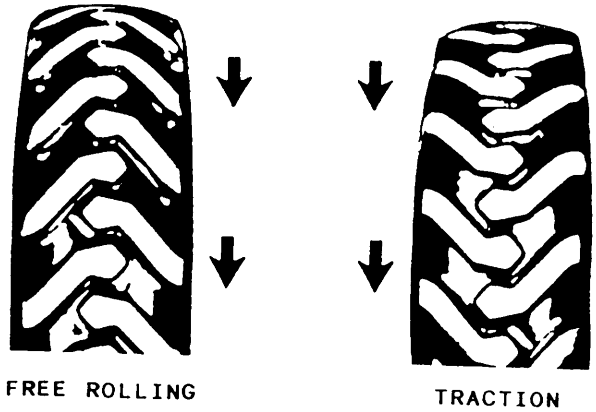

FREE ROLLING
TRACTION

Figure 3-19.-Mounting of directional tread tire.

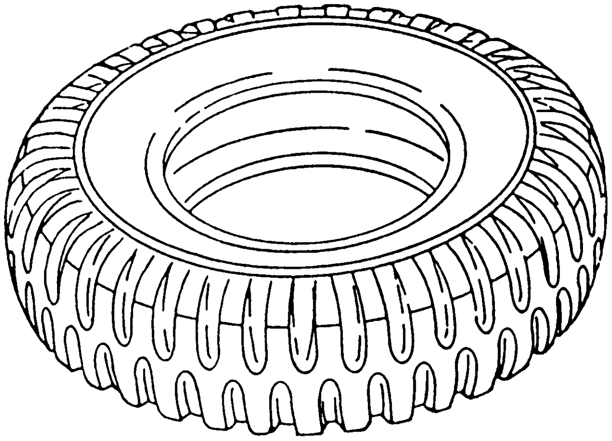


Figure 3-20.—Nondirectional mud or snow tread.

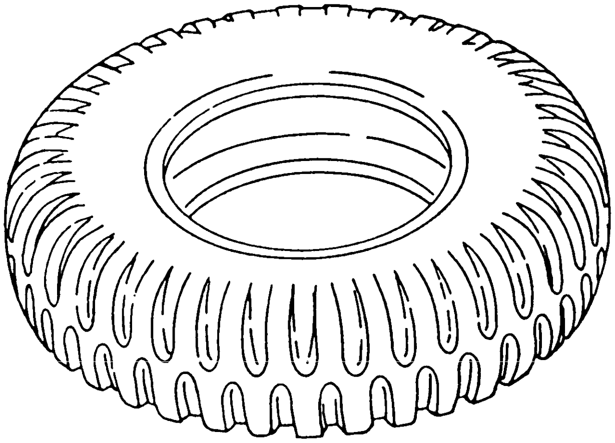


Figure 3-21.-Cross-country tread.

by improperly balanced tires, bad front-end alignment, or operating an all-wheel drive vehicle with the front-wheel drive engaged on hard-surfaced roads. This wear must be documented and turned in for repair.

TYPES OF TIRE TREADS

Tire treads are made for a specific purpose. The type of equipment you are operating and the type of job you are performing dictates what type of tire and tread you should use.

Directional Tread

The directional mud and snow tread (fig. 3-18) is of a V-design with large spaces between the lugs. The spaces between the lugs are kept free from snow because of tire rotation and flexing, therefore improving traction. A direction tire maybe mounted on the rim only in one way and delivers traction in one direction only. The point of the V-design must contact the ground first when traction is required. When directional tread tires are mounted on a dead or steering axle (unless the equipment is all-wheel drive), they are mounted so the open V meets the ground first (fig. 3-19). This type of tread is commonly found on graders.

Nondirectional Tread

The nondirectional mud and snow tread design (fig. 3-20) also has large spaces between the lugs. The lugs are placed perpendicular to the center line of the tire. This design provides good traction in both directions.

Cross-Country Tread

The cross-country tread (fig. 3-21) is the same as the mud and snow tread, except that the cross-country tread has rounded shoulders.

Regular Tread

Regular tread (fig. 3-22) consists of small spaces between tread patterns. This allows for a quiet ride and

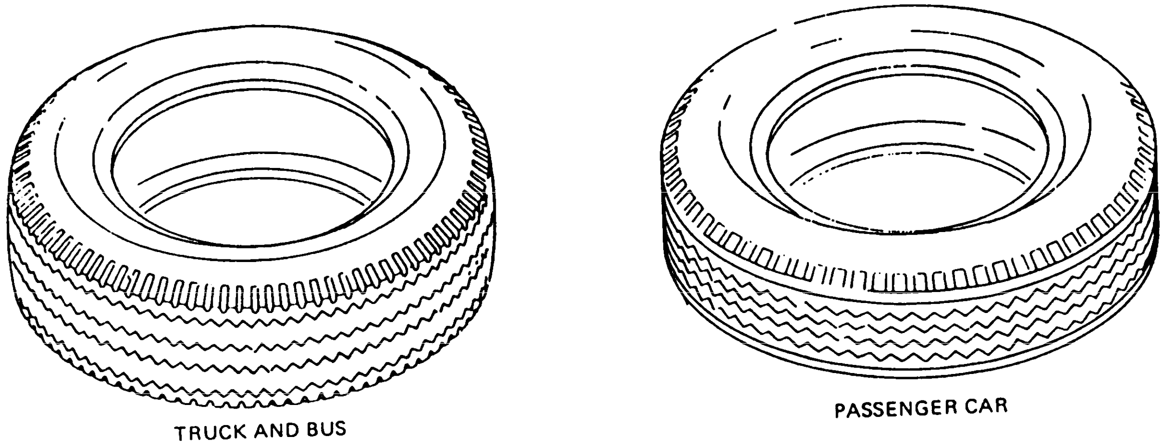


Figure 3-22.—Regular tread.

safe operation on wet and dry roads. This tread is often used on modern highway-operated tires.

Rock Service Tread

Rock service treads (fig. 3-23) are characterized by narrow voids between lugs so that loose rock cannot be caught and tear the tread lugs loose from the tire body. This nondirectional tread design is used on tires for service on rough terrain.

Earthmover Tread

The earthmover tread design (fig. 3-24) is for tires used on heavy equipment working in areas, such as a borrow pit or off-road service.

TIRE REMOVAL

Before removing a tire from a vehicle, ensure the emergency brake is locked and the transmission lever is in either park, first, or reverse, depending on the type of transmission. Locate something suitable for blocking the wheels to prevent the vehicle from rolling as you raise it with the jack. Never block the wheels on the axle you are raising with the jack.

For automobiles and light trucks, remove the hubcap, if so equipped, by using the lug wrench or a suitable substitute. Then slightly loosen the bolts or nuts that hold the wheel to the hub. Next, raise the wheel with the jack and observe the vehicle to ensure that it does not roll while being raised. If the vehicle starts to roll, lower the jack and add additional blocking to the wheels. Also, observe the jack and ensure that it does not sink into the ground from the weight of the vehicle. If the jack shows signs of sinking, move the vehicle to a more stable surface or place a plank of solid wood or steel matting under the jack to spread out the ground-bearing pressure. After the wheel has cleared the ground approximately 1 inch, finish removing the lug nuts or bolts and remove the wheel from the vehicle.

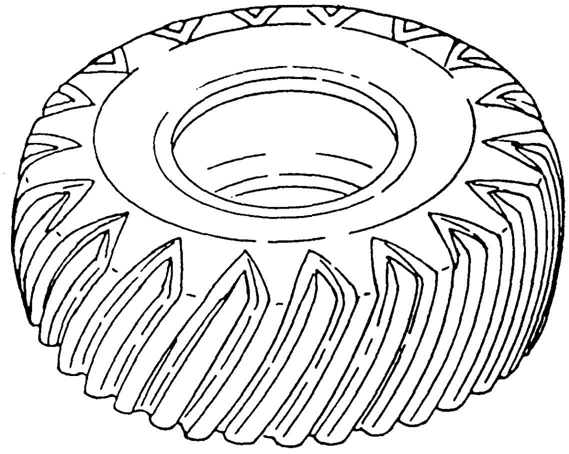


Figure 3-23.—Rock service tread.

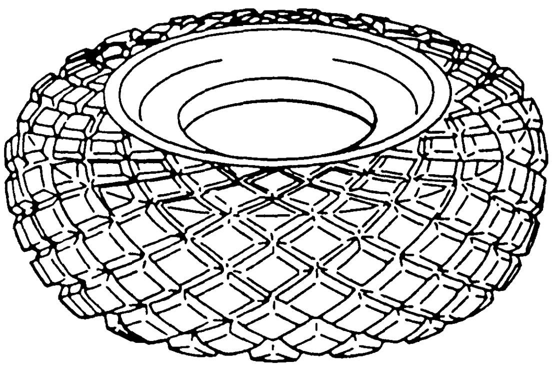


Figure 3-24.—Earthmover tread.

CAUTION

Do not leave the vehicle suspended on the jack. If work is to be performed on the vehicle while the tire is removed, place an approved safety stand or suitable blocks under the axle to support the vehicle. If no work is to be performed, install the spare tire as soon as possible to prevent damage to the vehicle or personnel.

On large vehicles with dual-disc wheels, both discs are fastened together by two nuts on each hub bolt, one

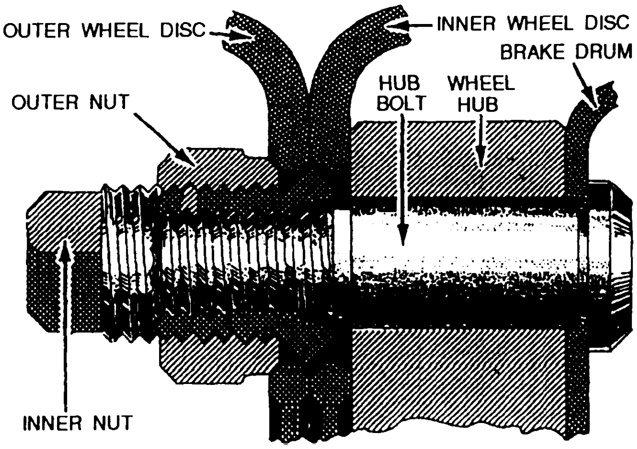


Figure 3-25.-Dual-disc wheel mounting.

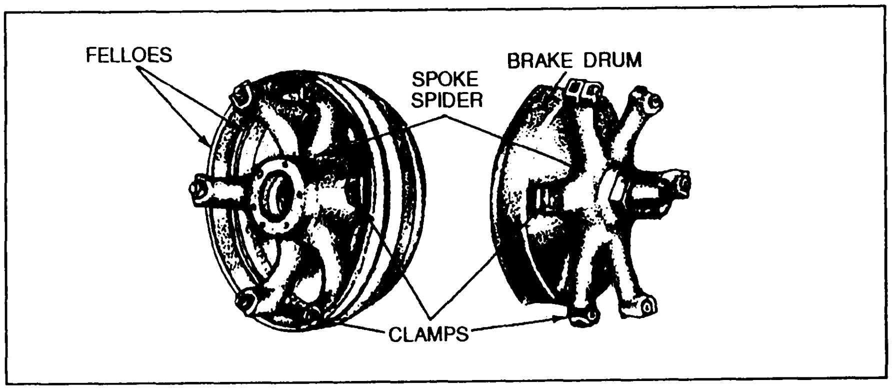


Figure 3-26.-Truck spoke wheels.

nut for each wheel. Either single or dual wheels can be securely mounted on the same hub with this arrangement. The outer nut must be loosened first to free the outer wheel disc from the hub. Loosening the outer nut, which threads over the inner nut, unfastens the outer wheel disc. In removing dual-disc wheels, you will find left-hand threads on both inner and outer nuts on the left wheels and right-hand threads on those of the right wheels.

Reverse the procedure to mount and tighten the wheels. Dual-disc wheel mounting is shown in figure 3-25.

On trucks having spoke wheels, remove the clamps which secure the rim on the spoke wheel (fig. 3-26), and lift off the rim with the tire and tube. If the spoke has two tires, the second rim and tire can be lifted off after the spacer separating the rims is removed. When installing the wheels, install the outer dual in a position that places the valve stem 180 degrees from the stem on the inner tire (fig. 3-27).

TIRE REPAIR

Facilities for repairing tires vary from one location to another. Some deployment locations have power-operated tire repair equipment to support tire repair. This

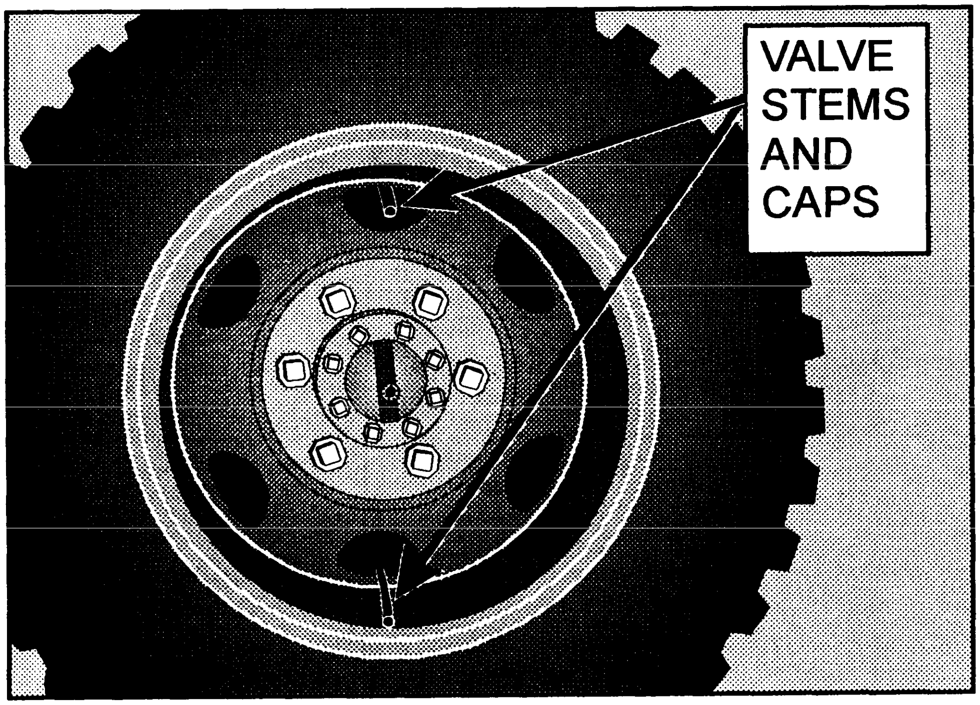


Figure 3-27.—180-degree valve stem location.

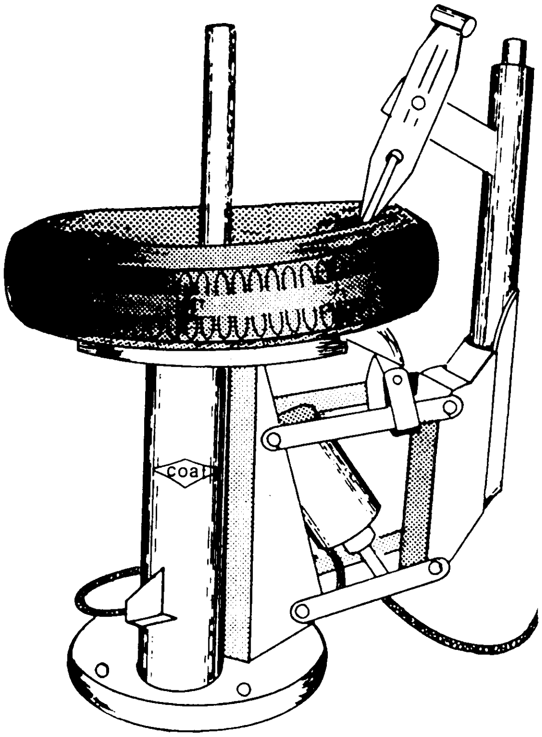


Figure 3-28.—Pneumatic tire demounter.

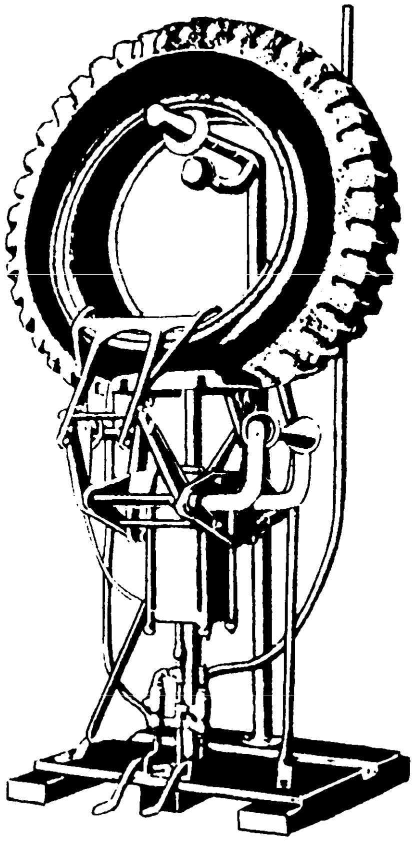


Figure 3-29.—Pneumatic tire spreader.

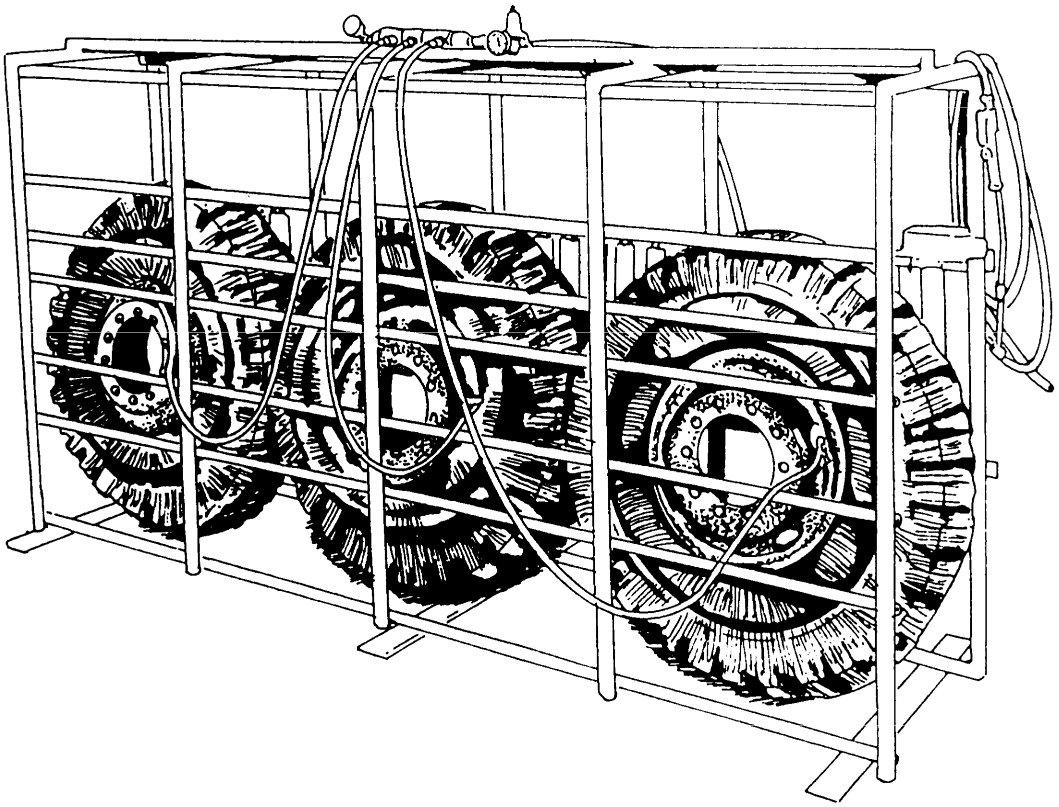


Figure 3-30.-Inflation safety cage.

equipment is similar to those shown in figures 3-28 and 3-29.

The first step in tire changing is to remove the valve core and deflate the tire completely. When using any tire repair equipment, install the tire and rim by closely following the manufacturer's instructions. The pneumatic tire demounter holds the wheel and tire still while it breaks the tire bead loose from the wheel rim. An adapter is used to remove the tire from or replace it on the rim. Tire demounters are manual, hydraulic, or air-operated. The one shown in figure 3-28 is an air-operated demounter for automotive and light truck tires.

NOTE: All of the related instructions for the use of tire shop equipment must be posted in the tire shop.

The spreader (fig. 3-29) separates the tire beads enough to allow close inspection and maintenance on the inside of the tire. When mounting a tire, inflate the tube until it is almost round. Put the inside bead of the tire on the rim and insert the tube into the tire with the valve at the balance mark on the tire. Place the valve stem through the hole and make sure that it is perpendicular to the hole. This step prevents chafing and damage to the valve stem during vehicle operation. When installing the second bead on the rim, start on the opposite side from the valve stem.

Place the tire and wheel in an APPROVED SAFETY CAGE (fig. 3-30). After mounting it on the rim, inflate the tire slowly. Make sure the tire beads fit snugly against the rim flanges. You may have to over-inflate the tire at first to make the bead seat on the rim. Once seated, allow the tire to deflate and install a new valve core. Then inflate the tire to the recommended pressure.

Unless your tire shop is well equipped, machinery for repairing truck tires, such as split rims and rims with removable side rings, may not be available or may not work on the various types of wheels and rims you may have to repair. When repairing tires with locking rings (fig. 3-31), first remove the valve core and deflate the tire. Force the tire bead away from the removable side ring with a slide hammer device intended for this purpose. Next, remove the side ring, as shown in figure 3-32, views A and B. Turn the wheel and tire over and

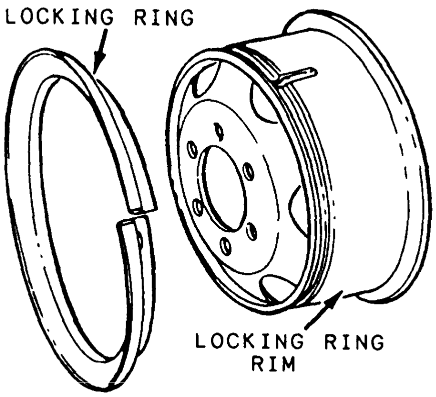
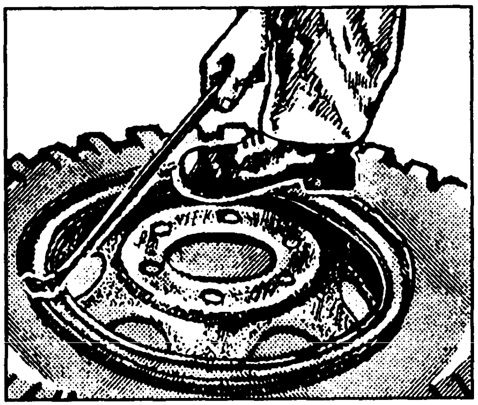
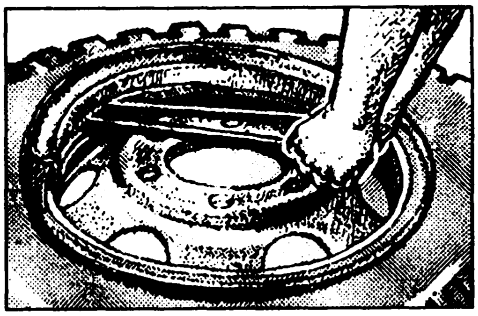


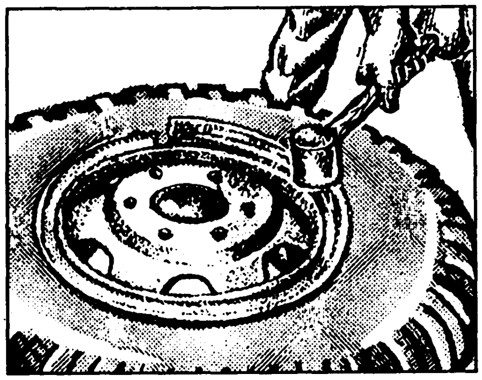
Figure 3-31.—Locking ring rim.



Ⓐ REMOVE VALVE CORE THEN START REMOVING THE SIDE RING AT THE NOTCH



Ⓑ ADVANCE THE TIRE IRONS AROUND THE RIM



Ⓒ AFTER INSTALLING ONE END, TAP AROUND IT WITH A LIGHT HAMMER

Figure 3-32.-Demounting and mounting a military truck tire.

loosen the other bead. Once the beads are broken, the tire can be removed from the rim by standing the tire on the thread and prying the wheel out of the tire. Ensure the valve stem is not bent or damaged as the wheel is removed.

To replace the tire, position the wheel, as shown in figure 3-32, view C. Lower the tire over the rim, and at the same time, make sure the valve stem is passed through the valve hole and points upward.

NOTE: The valve stem should always point toward the removable side ring. If there is no side ring, point it toward the disc portion of the wheel.

The next step is to center the side ring and force one end into position with your foot. Then the ring can be installed as shown, or the repair person can merely walk around the top of the ring and force it to slide into the locking groove. Inflating a tire mounted on a locking ring rim is dangerous. An improperly seated lock ring may blow off, causing serious injury to you or any other person in its path. A sprung ring, or one which is bent or twisted, may be difficult to install and, if used, is a safety hazard and should be replaced. Before applying air pressure to this tire, be sure that the locking ring is seated against the rim of the wheel through its entire circumference. If the lock ring does not seat properly, inflate it to 5 to 10 pounds, then tap the locking ring carefully with a mallet. NEVER STAND IN FRONT OF OR OVER THE LOCKING RING. ADDITIONALLY, REMEMBER TO USE THE SAFETY CAGE FOR INFLATION. When you have to inflate a tire that is already mounted, use a snap-on chuck which is an air hose that snaps onto the valve stem. This allows you to stand to one side of the tire. **Make it a professional practice to never stand in front of a tire being inflated.**

Tubeless Tire Repair

Some tires are tubeless. Instead of being sealed in an inner tube, the air in these tires is sealed in a space between the outer casing and the rim. Both this space and the point of contact of the tire against the rim must be airtight. The rim, on which the valve for inflating the tire is mounted, becomes a part of the air-retaining chamber. Do not tear or otherwise injure the sealing ribs.

Before replacing a tubeless tire, examine the rim carefully for dents, roughness, and rust; any defects may impair or break the air seal. Straighten out any dent with a hammer, and use steel wool or a wire brush to clean the bead seat area of any rust or grit. After cleaning, paint any bare metal spots where the tire bead seats to make it easier to remove the tire later. If the rim is badly damaged, replace it with a new one.

The procedure for repairing a tubeless tire is accomplished by the following steps:

1. Inspect the inside of the tire and remove nails or other damaging items. Then scrape the damaged area with a sharp-edged tool and buff (fig. 3-33, step 1). Be careful not to damage the liner or expose any cords.

NOTE: Serious injury can result using your bare hand to free for obstructions, use a rag to feel inside the tire.

2. Lubricate the hole by pushing bonding compound into the hole from both sides of the tire (fig. 3-33, step 2). Also, pour bonding compound on the insertion tool and push it through the hole with a twisting motion until it can be inserted and withdrawn easily.

3. Using a plug slightly larger than the hole, place it in the eye of the hole of the insertion tool. Wet the plug with bonding compound. Always pour it directly from the can so the contents in the can does not become contaminated, as shown in figure 3-33, step 3.

4. While stretching and holding the plug with your hand, insert the plug into the hole from the inside of the tire. Stretch and hold the plug until it is forced into the hole and one end extends through it, as shown in figure 3-33, step 4.

5. After the plug extends through the tire, remove the insertion tool and cut off the plug approximately 1/16 inch above the surface (fig. 3-33, step 5).

6. When using a cold patch, carefully remove the backing from the patch and center the base of the patch on the damaged area. Stitch the patch down firmly with the stitching tool working from the center out (fig. 3-33, step 6).

7. When using a vulcanizing hot patch, cover the area with a light coat of glue and allow it to dry. This glue normally comes with the hot patch kit. Remove the backing from the patch and center it on the damaged area. Clamp it finger tight, apply heat, allow to cure, and then cool. (fig. 3-33, step 7).

NOTE: Each patch or plug kit should contain specific instructions.

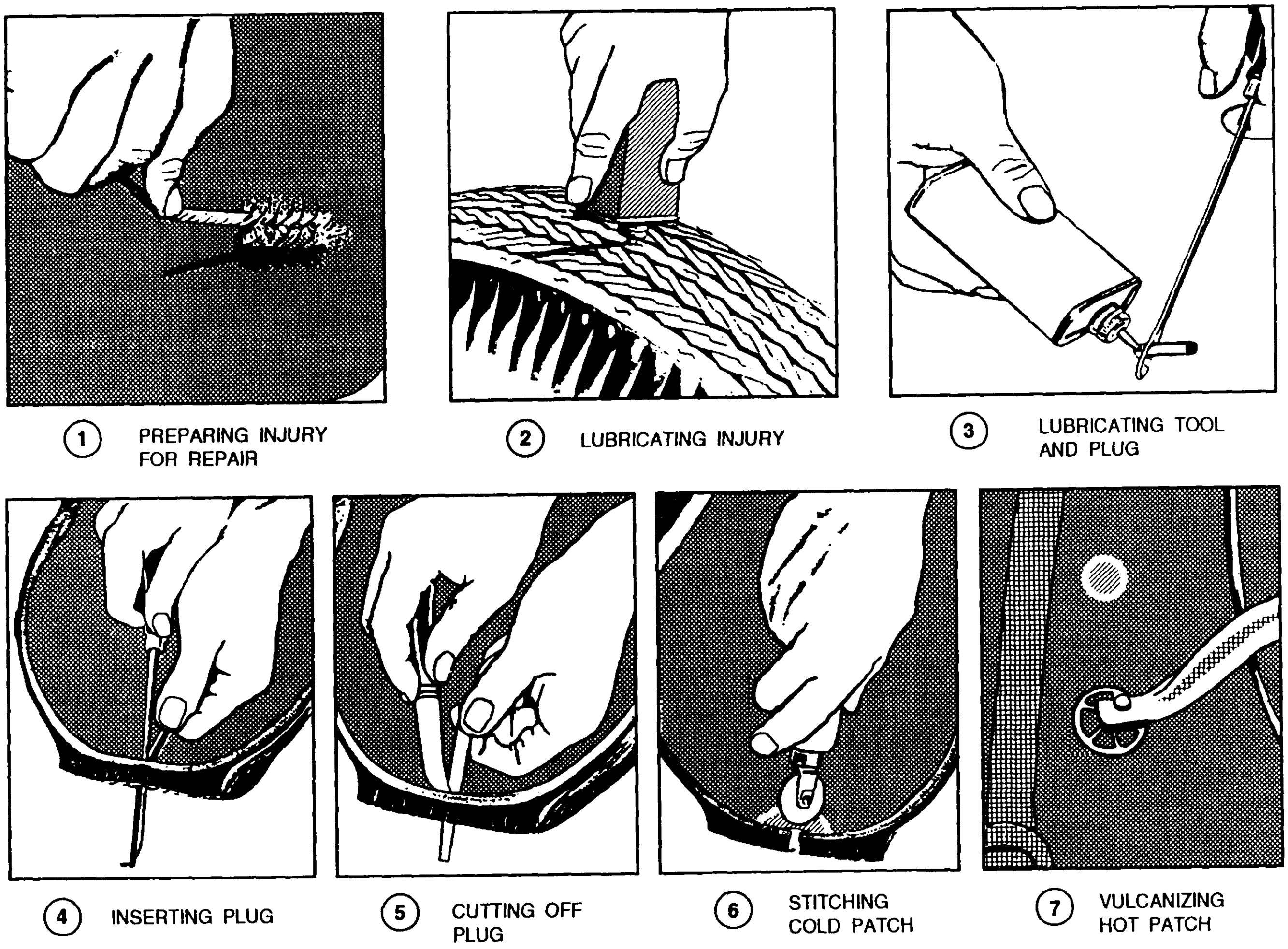


Figure 3-33.—Repair of tire punctures

Punctured tires can be repaired without being removed from the rim. In this case, the insertion of the plug is performed from the outside in, and steps 6 and 7 of figure 3-33 are not required.

NOTE: For radial-ply tires, repairs can only be made in the central tread area between the major grooves.

The procedures for removing and remounting a tubeless tire are similar to that for tube tires. If the seal is broken or defective, use a tube inside the tire; otherwise, the tire will lose air, and you will have to inflate it frequently. Some tubeless passenger car tires must be removed from the backside of the rim to prevent stretching the bead wires too far and causing them to break. If in doubt about any detail of the procedure for changing tubeless tires, follow the tire manufacturer's instruction or consult the maintenance supervisor.

Earthmover Tire Repair

When major damage or a blowout occurs or normal wear limits have been reached, the tire must be removed. Size alone makes the removal and replacement of earthmover tires difficult. Additionally, the nature of the terrain over which they operate often cause conditions to be far from ideal. Certain tools are necessary to change these large tires. The hydraulic bead breaker is specifically designed to break the giant beads for easier removal of the tire. BEFORE ATTEMPTING TO REMOVE THE TIRE, MAKE SURE THE WHEEL HAS BEEN JACKED UP AND THE EQUIPMENT PROPERLY BLOCKED FOR MAXIMUM SAFETY. After the equipment has been safely cribbed, deflate the tire completely by removing the valve core.

The clamping device is used to aid in unseating (breaking) the tire beads. Attached to the rim flange, it holds the hydraulic ram and shoe assembly. When securing the clamping device (fig. 3-34) to the rim, release the primary clamping device to permit full opening of the jaws. Hold the clamping device in a vertical position, as shown. Then hold the clamping device in place with one hand and tighten the large clamping screw lightly. Swing the reaction screw, as shown, until it is approximately perpendicular to the side of the rim flange. Turn the reaction screw in to bring the clamping device perpendicular to the rim. Tighten

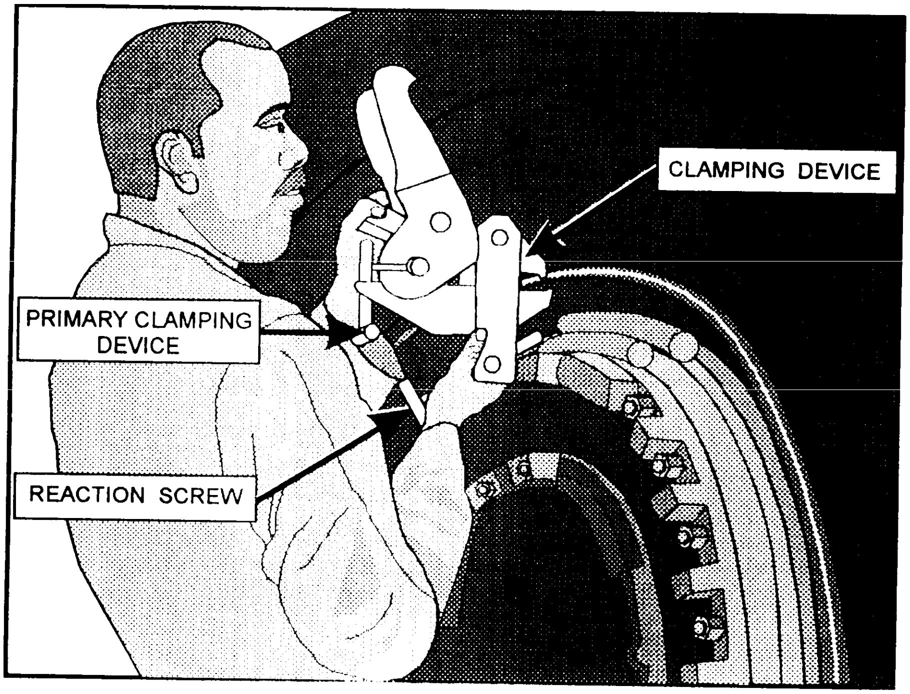

CLAMPING DEVICE
PRIMARY CLAMPING DEVICE
REACTION SCREW

Figure 3-34.—Clamping device.

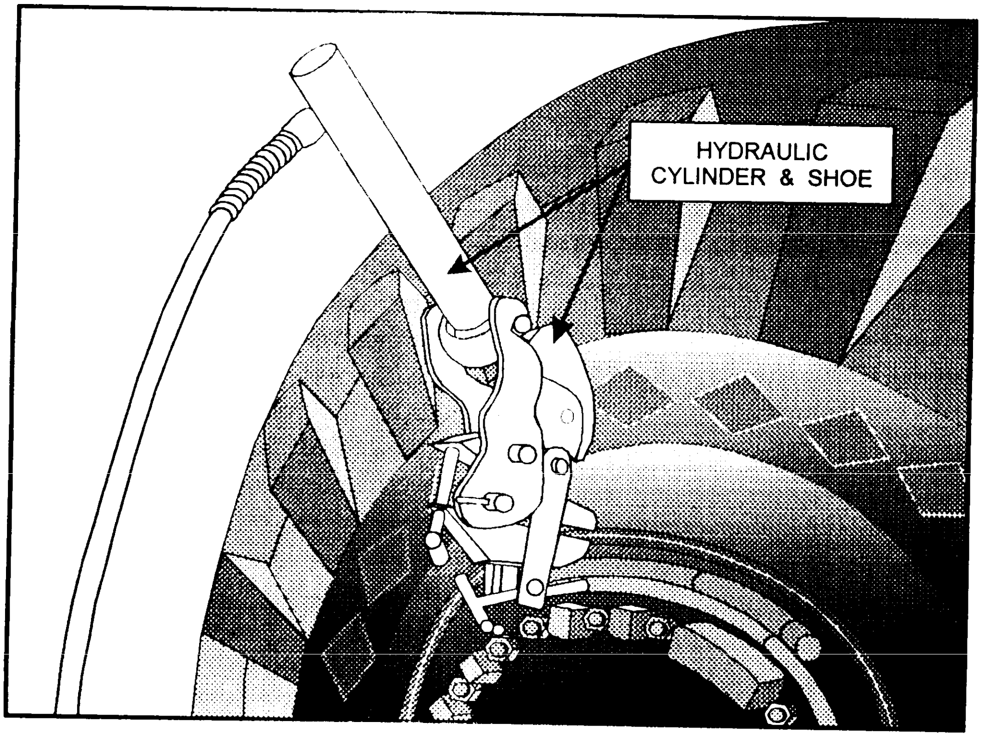

HYDRAULIC CYLINDER & SHOE

Figure 3-35.—Hydraulic cylinder and shoe.

the primary clamping screw firmly by hand. When the clamping device is secured in place, turn the handle on the bottom of the reaction screw. This handle swivels up and down to permit maximum movement of the clamping device side arms to ease hooking the ram cylinder into place.

The hydraulic cylinder and shoe assembly (fig. 3-35) are actuated by a pump. The pump applies hydraulic pressure that forces the ram with the attached shoe down between the rim flange and tire bead. This action separates the tire bead and rim.

When securing the ram to the clamping device, place the ram and shoe assembly between the arms of the clamping device where the bracket of the cylinder is secured into the notches of the clamping device side arms, as shown in figure 3-35.

Applying pressure to the hydraulic cylinder forces the shoe down over the clamping device, as shown in figure 3-35. The jaws of the clamping device acts as a guide for the shoe. The convex side of the shoe bears against the sidewall of the tire, forcing it inward between the tire bead and rim flange, thus breaking loose the bead from the rim.

Figure 3-36 shows how the wedges are placed on each side of the shoe assembly to hold the bead of the tire away from the rim flange so that the shoe assembly can be easily removed. After the shoe has been forced between the tire bead and rim flange and freed from that portion of the tire bead, the wedges are inserted to keep the tire bead separated from the rim. Pressure is then removed from the hydraulic cylinder slowly. The hydraulic cylinder and clamping device are then removed from the rim and the clamping device is placed approximately 90 degrees from the wedge. This process is continued until the tire bead is completely free from the rim flange.

Cold Patches

Cold patches are used to repair punctures and small breaks or holes in tubes. The procedure for applying a cold patch is accomplished by the following steps:

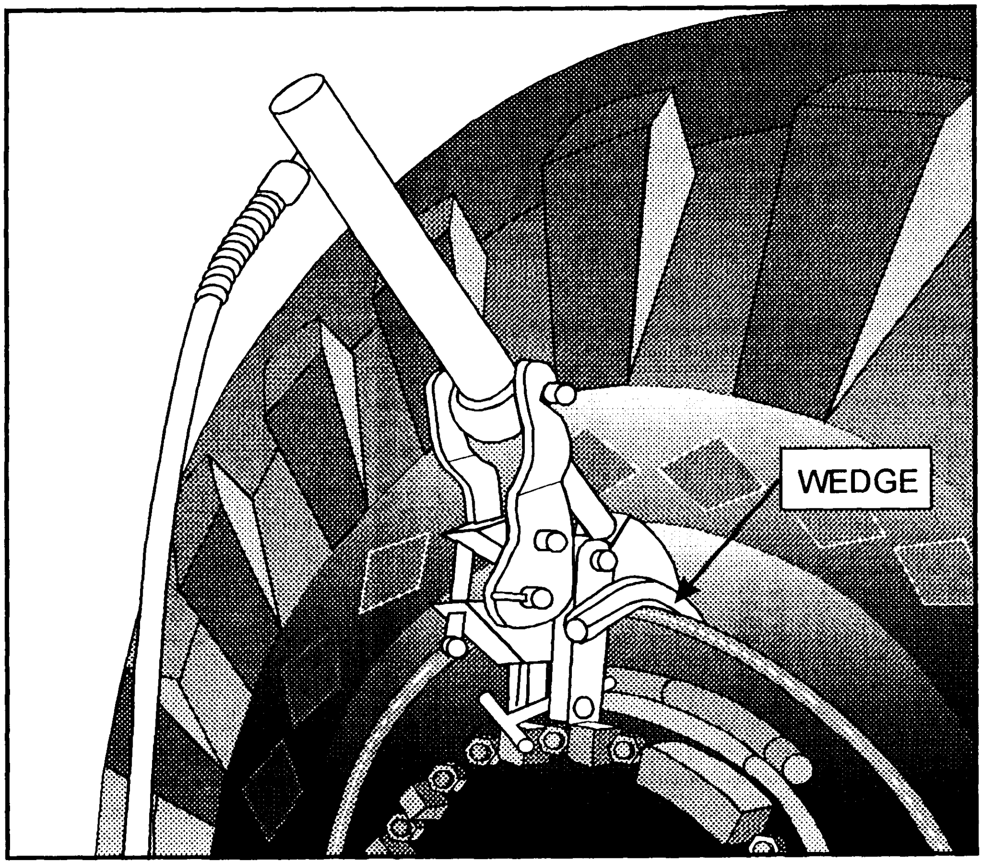


Figure 3-36.—Operation of hydraulic cylinder and shoe.

1. Buff or roughen the tube surface to be patched for at least 1 inch around the hole. Then clean it with solvent. When a buffer is not available, use the perforated cover of the kit as a scraper.

2. Apply a thin coat of rubber patching cement evenly over the roughened surface and allow it to dry.

3. From the kit, choose a patch of the proper size that is about 3/4 inch larger than the hole in the tube from the kit. Remove the protective covering from the sticky side of the patch; place the patch over the hole, and rub it down firmly.

4. Inflate the tube with enough air to check for leaks. If you cannot hear or feel air escaping from the patch, you can make another check by inserting the patched area in water. If no escaping air bubbles are noticed, the tube may be dried and replaced in the tire or stored.

Hot Patches

Hot patches consist of a slow burning block of fuel held in a notched metal pan on the bottom of which is a patch of uncured rubber. To apply a hot patch, follow the manufacturer's instructions on the kit.

Although methods of applying patches vary with the clamping devices provided and the shape of the patch, you clean and roughen the tube just as you did in applying the cold patch. When the patching unit is placed in the notches of the patch and clamped to the tube, the burning material is ignited, allowed to burn, and then removed after cooling for at least 5 minutes. After this, examine the completed patch to see if the edges of the patching material are attached securely to the tube. Then install the valve core and test the tube. Hot patches of assorted sizes are supplied in kits similar to the cold patch kits. You will also find pressure clamps and roughening tools in the hot patch kits.

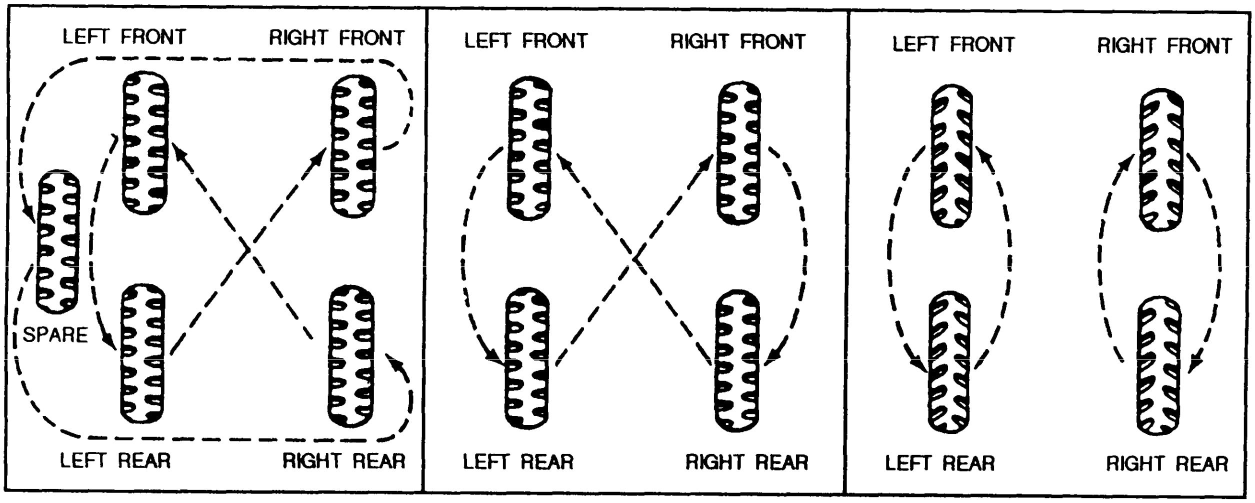
TIRE ROTATION

Rotating tires or changing them from one wheel to another so they wear evenly is recommended by the manufacturer. Tire rotation is performed to the manufacturer's specification for each vehicle. Examples of tire rotations are shown in figure 3-37.

TIRE SAFETY

The tire shop in most commands is supervised by the maintenance supervisor. When you are assigned to the tire shop, the maintenance supervisor should ensure you are briefed on tire safety by either the shop supervisor, the tire shop foreman, or the crew leader.

People inexperienced in tire repair should only repair tires when under the direct supervision of an experienced person. Additionally, always refer to the appropriate manufacturer's manuals for directions and instructions and remember: SAFETY COMES FIRST.



NONDIRECTIONAL TREAD WITH A SPARE

NONDIRECTIONAL TREAD WITH NO SPARE

DIRECTIONAL TREAD AND RADIAL PLY

Figure 3-37.-Tire and wheel rotation.

BRAKE SYSTEMS

Good brakes are a critical element for ensuring the safe operation of equipment. The brake system applies to all vehicles or equipment, such as pickup trucks, jeeps, tractor-trailers, and construction equipment. Braking systems must not only stop the unit but also must stop it in a smooth, uniform motion.

Friction is the resistance in relative motion between two surfaces in contact with each other. When a stationary surface is forced into contact with a moving surface, the rubbing action between the two surfaces slows down the moving surface. In nearly all brake systems, the brake drums provide the moving surface, and the brake shoes provide the stationary surface. The friction between the brake drum and the brake shoes slows the drum and wheel; and the friction between the tire and the road surface slows and stops the vehicle.

Part of your prestart and operator maintenance responsibilities consist of the following:

- Using the proper brake fluid
- Checking the brake fluid level
- Inflating tires properly
- Checking for loose connections or parts
- Checking for leaks in the system
- Draining air reservoirs daily
- Checking the self-contained lubricating oil system of air compressors daily

Brake troubles in vehicle operations that you may encounter and must document are as follows:

- The brake pedal goes to the floorboard with no resistance.
- One brake drags.
- All brakes drag.
- The vehicle pulls to one side when braking.
- Soft or spongy pedal.
- Excessive pedal effort required.
- Noisy brakes.
- Air in the system.
- Loss of brake fluid.
- The brakes heat up during driving and fail to release.
- Leaky brake cylinders.
- Grabbing braking action.
- The brake pedal can be depressed without slowing the vehicle.

INDIVIDUAL BRAKES

On modern equipment, individual service brakes are provided for each wheel and are operated by a foot pedal. The equipment also has an emergency or parking brake. The parking brake is operated by a separate pedal or a hand lever.

Individual brakes are classified as the external contracting brake, the internal expanding brake, the disc brake, and the mechanical parking brake.

External Contracting Brakes

External contracting brakes are sometimes used for parking brakes on motor vehicles, for cranes, and for controlling the speed of auxiliary equipment drive shafts.

In operation, the brake band (or shoe) of an external contracting brake is tightened around the rotating drum by moving the brake lever. The brake band is made of comparatively thin, flexible steel, shaped to fit the drum, with a frictional lining riveted to the inner surface (fig. 3-38). his flexible band cannot withstand the high pressure required to produce the friction needed to stop a heavily loaded or fast-moving vehicle, but it works well as a parking brake or hold brake.

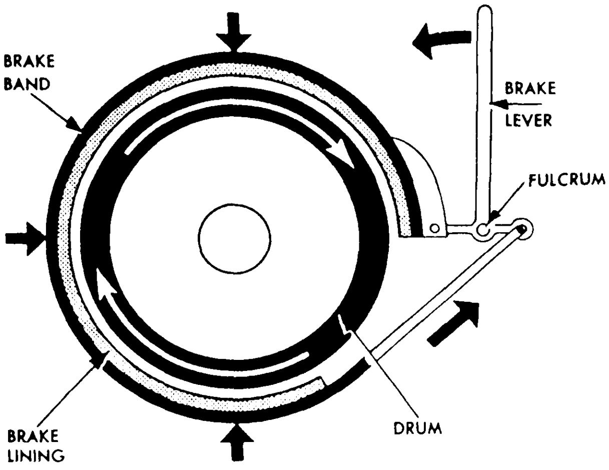


Figure 3-38.-External contracting brake.

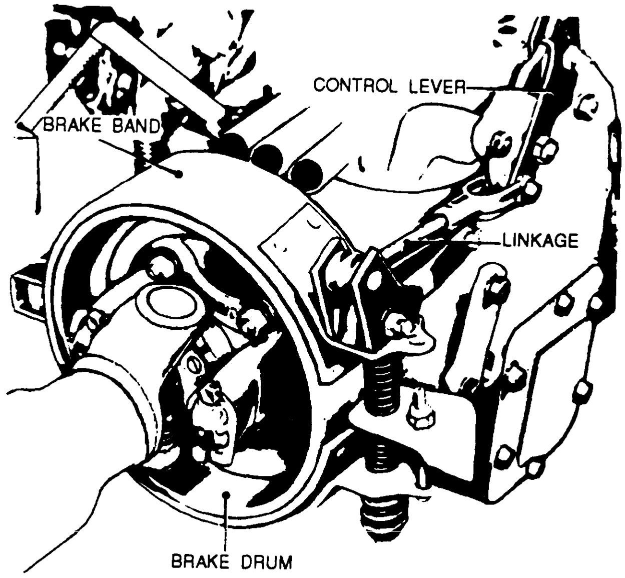

CONTROL LEVER
BRAKE BAND
LINKAGE
BRAKE DRUM

Figure 3-39.—External contracting transmission parking brake.

Figure 3-39 shows an external contracting brake. The brake band is anchored opposite the point where the pressure is applied. In addition to supporting the band, the anchor allows adjustment of the brake lining clearance. Other adjusting screws and bolts are provided at the ends of the band.

Internal Expanding Brakes

Internal expanding brakes are used almost exclusively as wheel brakes, but can be found on some cranes. This type of brake permits a more compact and economical construction. The brake shoes and brake-operating mechanism are supported on a backing plate or brake shield attached to the vehicle axle, as shown in figure 3-40. The brake drum, attached to the rotating wheel, acts as a cover for the shoe and operating mechanism and furnishes a frictional surface for the brake shoes.

The brake shoe of an internal expanding brake is forced outward against the drum to produce the braking action. One end of the shoe is hinged to the backing plate by an anchor pin, while the other end is unattached and can be moved in its support by the operating mechanism. When force from the operating mechanism is applied to the unattached end of the shoe, the shoe expands and brakes the wheel. A retracting spring returns the shoe to the original position when braking action is no longer required.

Disc Brakes

The disc brake has a metal disc (rotor) and a pair of flat brake pads instead of a drum and curved brake shoes. Figure 3-41 shows a sectional view of a disc brake assembly. The two flat pads are on the two sides of the disc. The assembly in which the flat pads are held is the caliper assembly. In operation, the pads are forced against the two sides of the disc by the movement of the pistons in the caliper assembly. The pistons are actuated by hydraulic pressure from the master cylinder. The effect is to clamp the rotating disc between the stationary pads, as shown in figure 3-41.

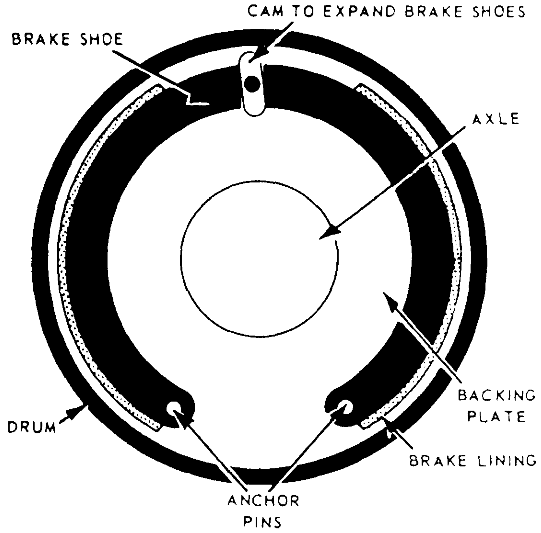

CAM TO EXPAND BRAKE SHOES
BRAKE SHOE
AXLE
BACKING PLATE
BRAKE LINING
DRUM
ANCHOR PINS

Figure 3-40.-Internal expanding brake.

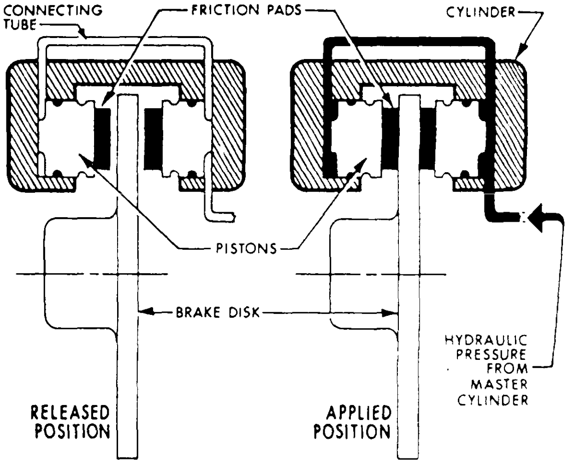

CONNECTING TUBE
FRICTION PADS
CYLINDER
PISTONS
BRAKE DISK
HYDRAULIC PRESSURE FROM MASTER CYLINDER
RELEASED POSITION
APPLIED POSITION

Figure 3-41.-Sectional view of a disc brake.

Mechanical Parking Brake

In most vehicles, a hand lever or foot pedal engages the parking brake. The parking brake has its own system and can be either an external contracting brake bands on the drive shaft (fig. 3-42, view A) or a mechanical linkage that works the rear wheel brakes (fig. 3-42, view B).

HYDRAULIC BRAKE SYSTEM

A hydraulic brake system is primarily a liquid connection or coupling between the brake pedal and the individual brake shoes and drums, as shown in figure 3-43. The system consists of one master cylinder connected by pipes and flexible tubing to the wheel cylinders. The wheel cylinders control the movement of the brake shoes at each wheel. When the brake pedal is depressed, the hydraulic fluid forces the pistons in the wheel cylinder against the brake shoes, forcing the shoes against the brake drum or brake discs stopping the wheels.

Hydraulic brakes are self-equalizing brakes. If the actuating pistons were all the same size, each brake in the hydraulic system would receive an identical hydraulic force when the brakes were applied, because a force exerted at any point upon a closed liquid is distributed equally through the liquid in all directions at the same time. All brake systems have larger wheel cylinders in the front than in the rear. When you stop a vehicle, more weight is automatically shifted forward due to inertia, so more front-wheel braking is required.

The master cylinder is a reservoir for the brake fluid and contains pistons and valves which change mechanical force to hydraulic pressure when the brake pedal is depressed, as shown in figure 3-43. The pressure on the brake pedal moves the piston within the master cylinder to force the brake fluid from the master cylinder through tubing and flexible hoses to the wheel cylinders. As pressure on the pedal is increased, greater hydraulic pressure is built up within the brake cylinders, and thus greater force is exerted against the ends of the brake shoes. When pressure on the pedal is released, the retracting springs on the brake shoes return the wheel cylinder pistons to their released positions. This action forces the brake fluid back through the flexible hose and tubing to the master cylinder.

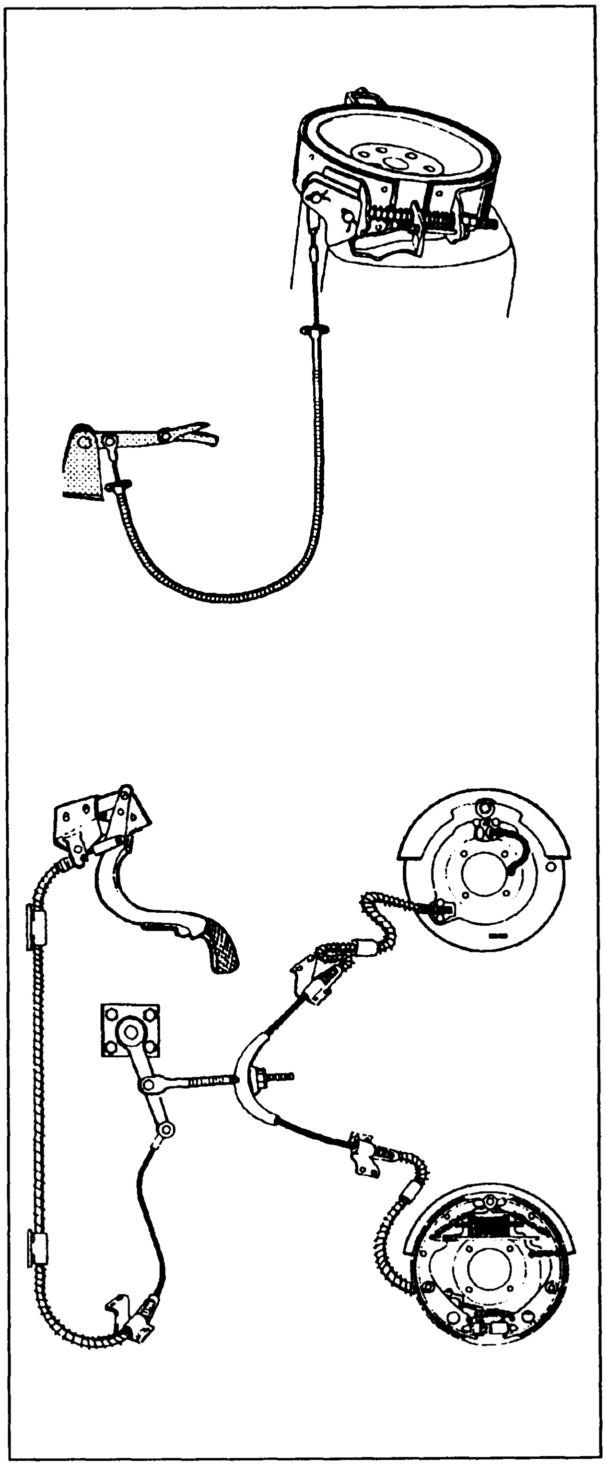


Figure 3-42.-Parking brake configurations.

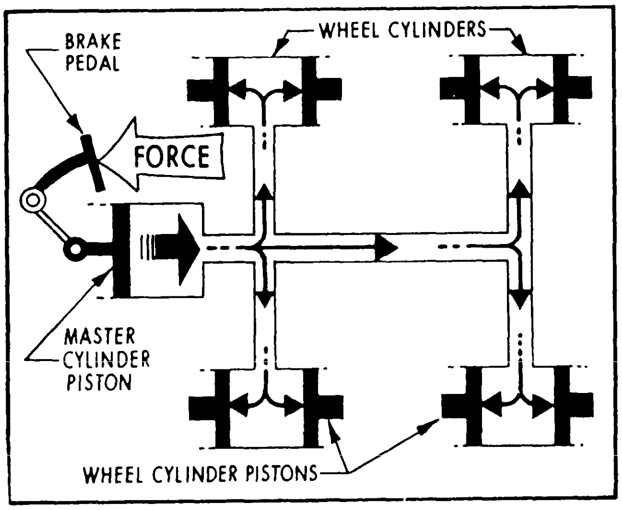


Figure 3-43.-Hydraulic brake system.

The operation of a dual system master cylinder is basically the same as a single master cylinder. However, the dual system master cylinder has two separate hydraulic pressure systems. One of the hydraulic systems normally is connected to the front brakes and the other system to the rear brakes. If either the front or rear hydraulic system fails, the other system remains operational.

The master cylinder, like other parts in the brake system, is subject to wear, leaks, and deposits or corrosion on the cylinder wall and piston. Part of your prestart operation is to check the cylinder reservoir fluid level and add clean brake fluid to maintain the manufacturer's specifications.

The brake lines transmit fluid and pressure from the master cylinder to the wheel cylinders, which are mounted on the brake-backing plate, and change the hydraulic pressure into mechanical force. Inside each cylinder are two pistons that move in opposite directions by hydraulic pressure which pushes the brake shoes against the brake drum or disc. The brake shoes are made of steel that transmits force to the lining which is attached to the face of the shoe and makes contact with the brake drums or discs. During contact with one another, the lining and the drum or disc create the frictional surface that gives the braking effect.

AIR BRAKE SYSTEM

An air brake system uses compressed air to apply the brakes. Air under pressure can be conveniently stored and carried through lines or tubes. Considerable force is available for braking since operating air pressure may be as high as 100 psi. All brakes on a vehicle and on a trailer (when one is used) are operated together by a brake valve. This valve and the relative location of most of the basic assemblies of an air brake system are shown in figure 3-44.

Air Compressor

The air compressor pumps air into the air storage tanks (reservoirs). The air compressor is driven by the engine through gears or a V-belt. The compressor may be air-cooled or may be cooled by the engine lubrication system. It may have its own oil supply or be lubricated by engine oil. If the compressor has its own oil supply, the oil should be checked during your prestart operations.

Governor

The governor controls the air compressor output. When air tank pressures rise to the cutout level at about

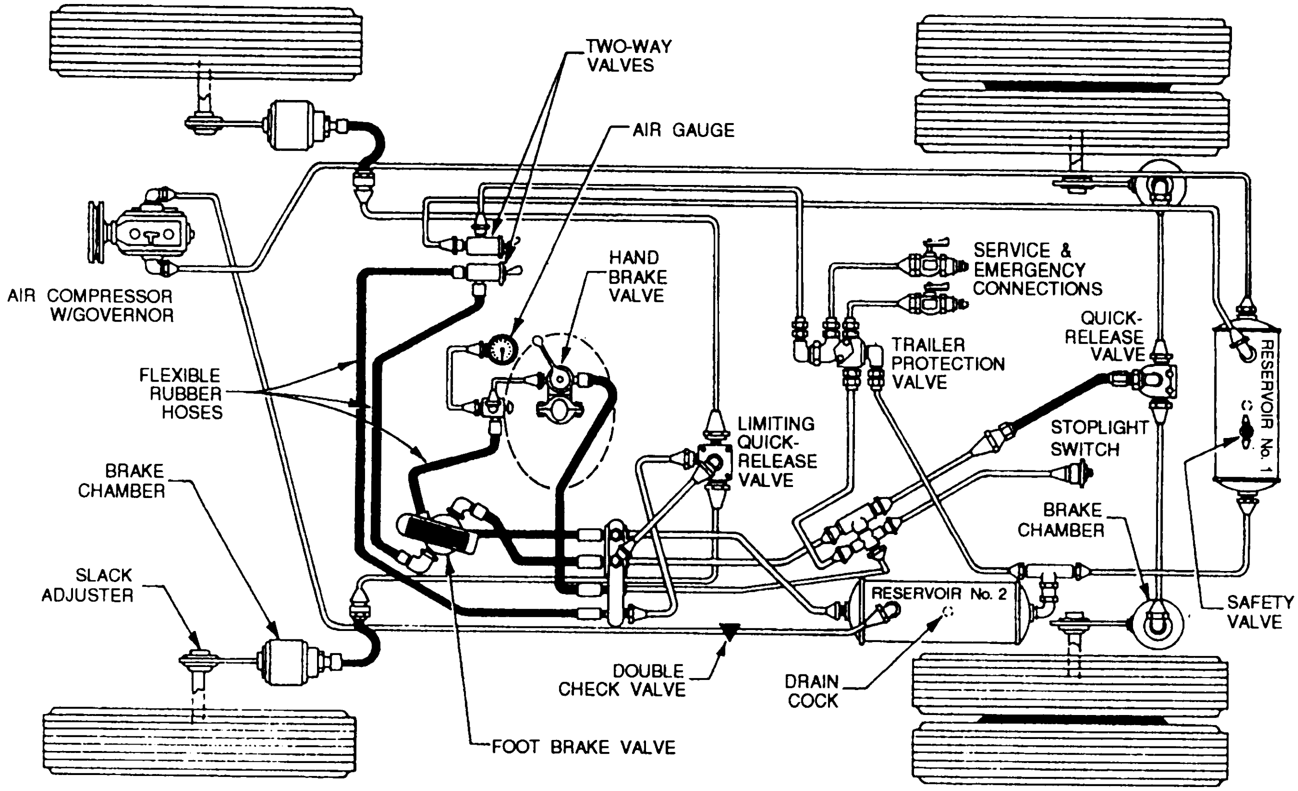

TWO-WAY VALVES
AIR GAUGE
HAND BRAKE VALVE
SERVICE & EMERGENCY CONNECTIONS
AIR COMPRESSOR W/GOVERNOR
QUICK-RELEASE VALVE
TRAILER PROTECTION VALVE
RESERVOIR No. 1
FLEXIBLE RUBBER HOSES
LIMITING QUICK-RELEASE VALVE
STOPLIGHT SWITCH
BRAKE CHAMBER
BRAKE CHAMBER
SLACK ADJUSTER
RESERVOIR No. 2
SAFETY VALVE
DOUBLE CHECK VALVE
DRAIN COCK
FOOT BRAKE VALVE

Figure 3-44.—Typical air brake system.

125 pounds per square inch (psi), the governor stops the compressor from pumping air. When the tank pressure falls to the **cut-in** pressure at about 100 psi, the governor allows the compressor to start pumping again.

Air Storage Tanks

Air storage tanks (reservoirs) are used to hold compressed air. The number and size of air tanks varies among vehicles. The tanks hold enough air to allow the brakes to be used several times, even if the compressor stops working.

NOTE: Compressed air usually has some water and some compressor oil in it which is bad for the air brake system. For example, the water can freeze in cold weather and cause brake failure. The water and oil tend to collect in the bottom of the air tank; therefore, each air tank is equipped with a drain valve in the bottom.

The two types of drain valves areas follows:

1. The manual valve shown in figure 3-45 is operated by turning it a quarter turn or by pulling a cable. Part of your post-operational procedures is to drain all air tanks at the end of each day.

2. The automatic valve automatically expels the water and oil. This system may also be equipped with a manual drain.

Alcohol Evaporator

Some air brake systems have an alcohol evaporator to put alcohol into the air system. This helps reduce the risk of ice in air brake valves and other parts during cold weather. Ice inside a brake system can make the brakes stop working.

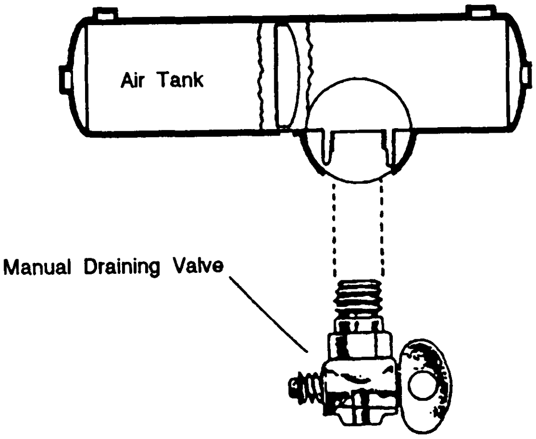


Figure 3-45.-Air tank manual drain valve.

If your vehicle has an alcohol system, the container should be checked during each prestart operation and filled up as necessary. Daily draining of the air tanks is still required to get rid of the water and oil.

Safety Valve

A safety relief valve is installed in the first tank into which the air compressor pumps air. The safety valve protects the tank and the rest of the system from too much pressure. The valve is usually set to open at 150 psi. If the safety valve has to release air pressure, something is wrong in the air brake system. This should be documented to inform the mechanic inspectors.

Brake Pedal

The brakes are applied by depressing the brake pedal (also called the foot valve, or treadle valve) that gives the operator control of the air brake system. When the brake pedal is engaged, air from the air tanks flows through the brake pedal valve through the brake lines to the brake chambers close to the wheel brakes that contain flexible diaphragms. The force of the air admitted into these chambers causes the diaphragms to operate the brake shoes through a mechanical linkage.

Pushing the pedal down harder applies more air pressure. Letting up on the brake pedal reduces the air pressure and releases the brakes. Releasing the brakes allows some compressed air out of the system; therefore, the air pressure in the tanks is reduced and it must be recharged by the air compressor. Pressing and releasing the pedal unnecessarily may release air out faster than the compressor can replace it, and should the pressure become too low, the brakes cannot work properly and brake failure will occur.

Pressure Gauge

An air pressure gauge lets you know if you have proper air pressure within the reservoir. A low air warning device should cut on before the pressure drops to less than 60 psi in the air tank. This gauge is usually on the instrument panel of a truck or bus. If the pressure fails to buildup or exceeds the maximum limits after building up, secure the truck until the fault is corrected.

Hand Brake Valve

Independent control of brakes is necessary under bad conditions, especially if you have to put on the

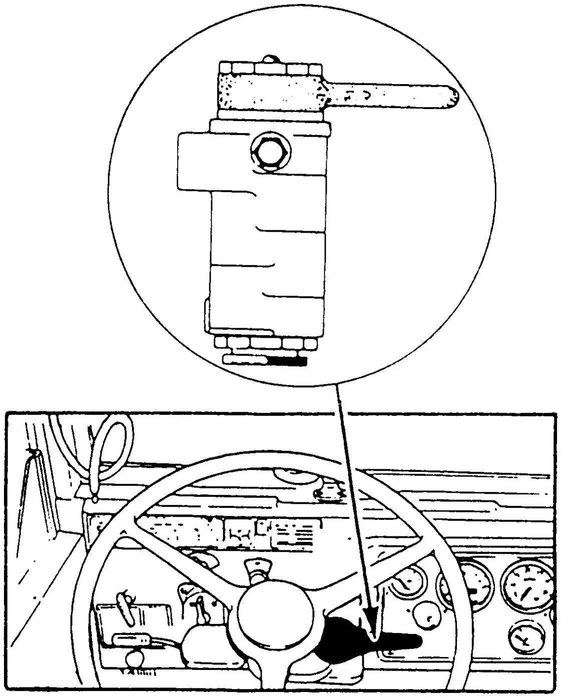


Figure 3-46.—Hand brake valve.

trailer brakes without applying the truck or tractor brakes. The hand brake valve or independent trailer control valve, as shown in figures 3-44 and 3-46, provides the operator control of the trailing load at all times.

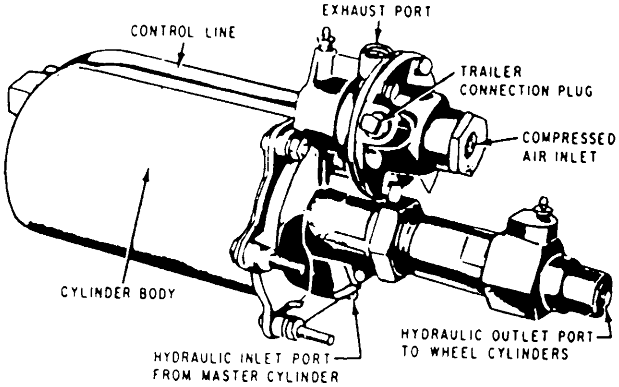

EXHAUST PORT
CONTROL LINE
TRAILER CONNECTION PLUG
COMPRESSED AIR INLET
CYLINDER BODY
HYDRAULIC OUTLET PORT TO WHEEL CYLINDERS
HYDRAULIC INLET PORT FROM MASTER CYLINDER

Figure 3-48.-Air-over-hydraulic power cylinder.

NOTE: More information about the air brake system is in the chapter covering tractor and trailer operations.

AIR-OVER-HYDRAULIC BRAKE SYSTEM

An air-over-hydraulic brake system is shown in figure 3-47. This system combines the use of compressed air and hydraulic pressure for brake operation. The air-over-hydraulic brake system has an air-over-hydraulic power cylinder (fig. 3-48) that contains an air cylinder and a hydraulic cylinder in tandem. Each cylinder is fitted with a piston and a common rod. The air piston is of greater diameter than the hydraulic piston. This difference in the two pistons

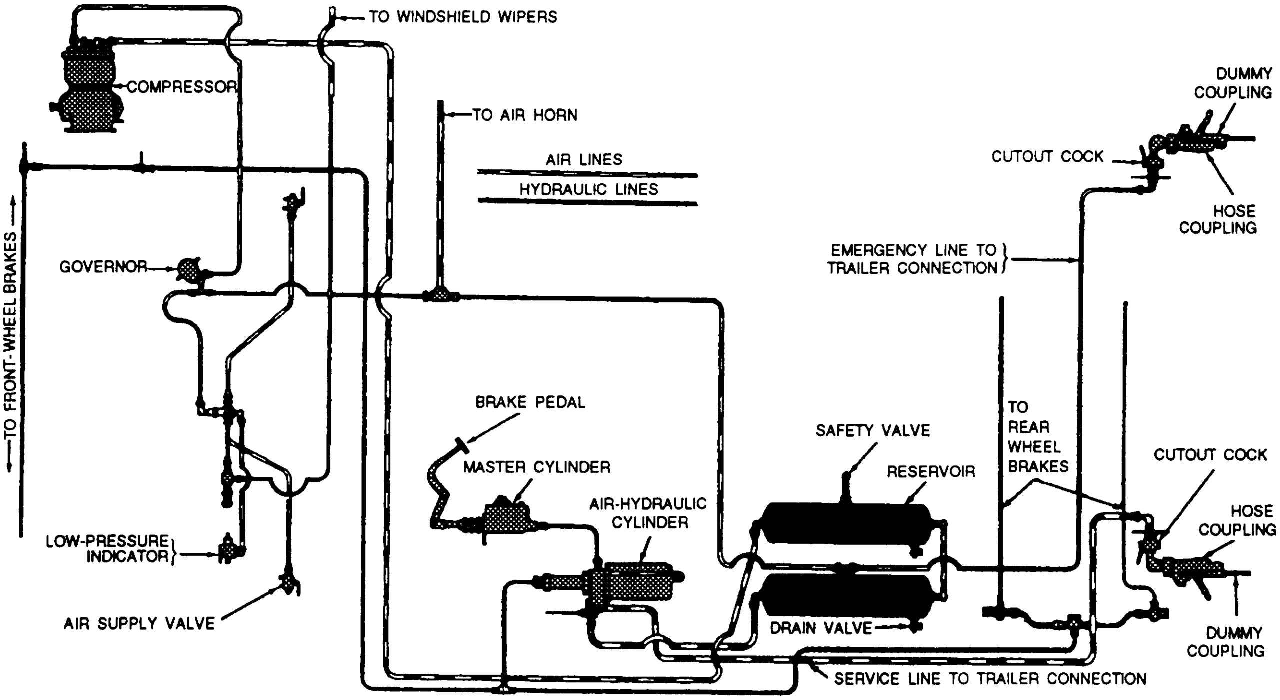

TO WINDSHIELD WIPERS
COMPRESSOR
TO AIR HORN
AIR LINES
HYDRAULIC LINES
DUMMY COUPLING
CUTOUT COCK
HOSE COUPLING
EMERGENCY LINE TO TRAILER CONNECTION
TO FRONT-WHEEL BRAKES
GOVERNOR
BRAKE PEDAL
MASTER CYLINDER
SAFETY VALVE
RESERVOIR
TO REAR WHEEL BRAKES
CUTOUT COCK
HOSE COUPLING
AIR-HYDRAULIC CYLINDER
LOW-PRESSURE INDICATOR
AIR SUPPLY VALVE
DRAIN VALVE
DUMMY COUPLING
SERVICE LINE TO TRAILER CONNECTION

Figure 3-47.-Typical air-over-hydraulic brake system.

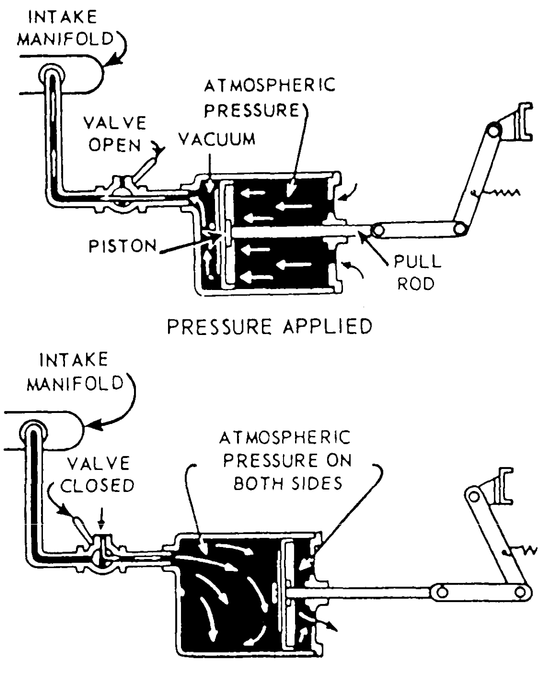

INTAKE MANIFOLD
ATMOSPHERIC PRESSURE
VALVE OPEN
VACUUM
PISTON
PULL ROD
PRESSURE APPLIED
INTAKE MANIFOLD
ATMOSPHERIC PRESSURE ON BOTH SIDES
VALVE CLOSED

Figure 3-49.-Typical vacuum brake cylinder.

results in much greater hydraulic pressure than air pressure admitted to the air cylinder. Valve action varies with the amount of pressure applied to the brake pedal. When heavy brake pedal pressure is applied by the operator for hard braking, the hydraulic pressure in the master cylinder (which operates the valves) causes greater valve movement. As a result, the valve admits more air pressure into the air-over-hydraulic power cylinder and this higher air pressure causes a stronger braking action.

VACUUM BRAKES

In a vacuum brake system, depressing the brake pedal opens a valve between the power cylinder, which contains a piston, and the intake manifold to which the power cylinder is connected (fig. 3-49). When you apply the brakes, air is exhausted from the cylinder head of the piston. At the same time, atmospheric pressure acts on the rear side of the piston to exert a powerful pull on the rod attached to the piston.

When the brake valve is closed, the chamber ahead of the piston is shut off from the intake manifold and is opened to the atmosphere. The pressure is then the same on both sides of the piston; therefore, no pull is exerted upon the pull rod. The brakes are released and the piston returned to its original position in the power cylinder by the brake shoe return springs.

Hydrovac™ is a trade name for a one-unit vacuum power-braking system. It combines a hydraulic control valve, a vacuum power cylinder, and a hydraulic slave cylinder into one assembly. This assembly (fig. 3-50) is connected to both the master cylinder and the wheel brakes and eliminates the need for mechanical connections with the brake pedal.

Pressure on the brake pedal forces fluid from the master cylinder through the check valve to the slave cylinder and to the wheel cylinders. Also, the foot pedal pressure, acting through the master cylinder, acts also against the slave cylinder piston to help the vacuum pistons and pushrods to press against the brake shoes.

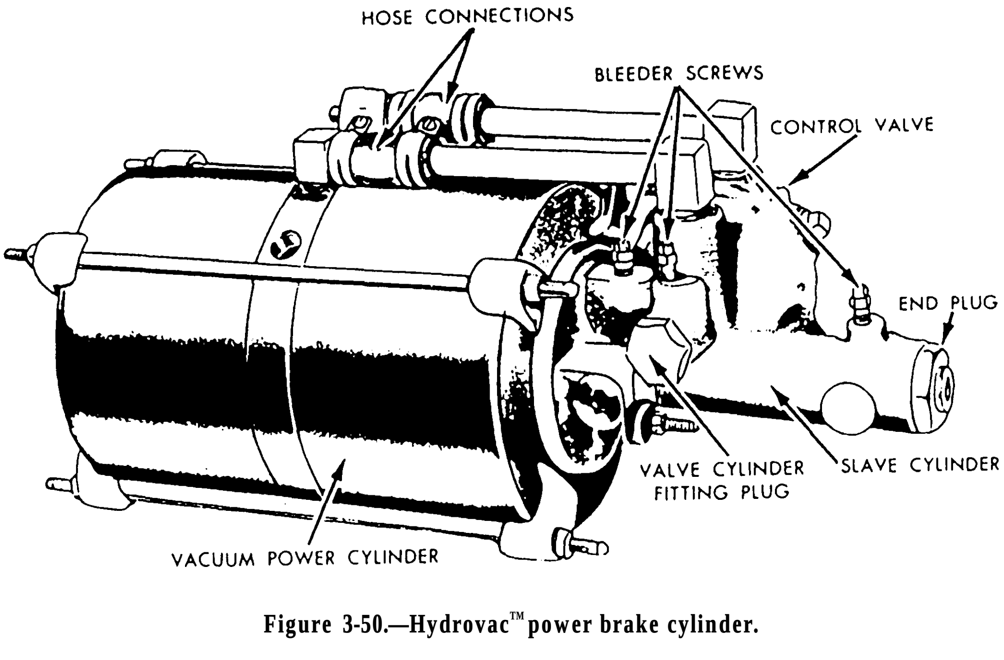

HOSE CONNECTIONS
BLEEDER SCREWS
CONTROL VALVE
END PLUG
VALVE CYLINDER FITTING PLUG
SLAVE CYLINDER
VACUUM POWER CYLINDER

Figure 3-50.—Hydrovac™ power brake cylinder.

CHAPTER 4

ELECTRICAL AND HYDRAULIC SYSTEMS

The electrical and hydraulic systems are major components designed to perform a variety of functions that support the operation of equipment. These systems control starting, charging, braking, steering, lifting, and the movement of all attachments. This chapter covers the basic components of the electrical and hydraulic systems used in automotive and construction equipment.

ELECTRICAL SYSTEMS

Proper performance of pre- and post-operational checks and operator maintenance requires a basic understanding of the electrical systems used on automotive and construction equipment. The basic components of the electrical system are the following: a storage battery, a charging system, starting circuits, a lighting system, and gauges.

STORAGE BATTERY

The storage battery is the heart of the charging circuit. The type used in automotive, construction, and weight-handling equipment is a lead-acid cell type of battery. This type of battery stores energy in a chemical form. It is not a storage tank for electricity.

The battery acts as a stabilizer for the voltage of the electrical system and may, for a limited time, furnish current when the electrical demands of the vehicle exceed the generator output. The battery produces a flow of direct current when lights, starter motor, or other current-consuming devices are connected to the battery posts. This current is produced by a chemical reaction between the active materials of the plates and the sulfuric acid of the electrolyte.

Part of your prestart and operator maintenance responsibilities are checking the battery water level and ensuring the battery terminals are tight and free from corrosion. You can clean a battery thoroughly by using a stiff brush and a water and baking soda solution. If the battery terminals are corroded, disconnect and clean them. Clean the battery posts and the inside of the connectors so they make good electrical contact. After cleaning, you should rinse off the battery with clean water. If the battery fails to supply sufficient power to turn the starter, document it and turn it in.

Battery Construction

A typical lead-acid storage battery is shown in figure 4-1. Like most batteries, it consists of a molded container with individual cell compartments, cell elements, cell connectors, cell covers, terminal posts, and vented filler caps.

The container is made of molded hard rubber, plastic, or bituminous material. It must withstand shock and vibration as well as the heat of the engine compartment, if so located. Each cell compartment has rests to support the elements and space for an adequate supply of electrolyte. An area between the element rests allows any material from the elements to settle without contacting the elements and causing an internal short.

The cell elements contain two types of lead plates, known as positive and negative. These plates are insulated from each other by suitable separators made of microporous, nonconductor material (usually porous rubber or spun glass) and are submerged in a sulfuric acid solution (electrolyte).

Batteries are designed with a single cover that extends over all cells. In many batteries, only the filler

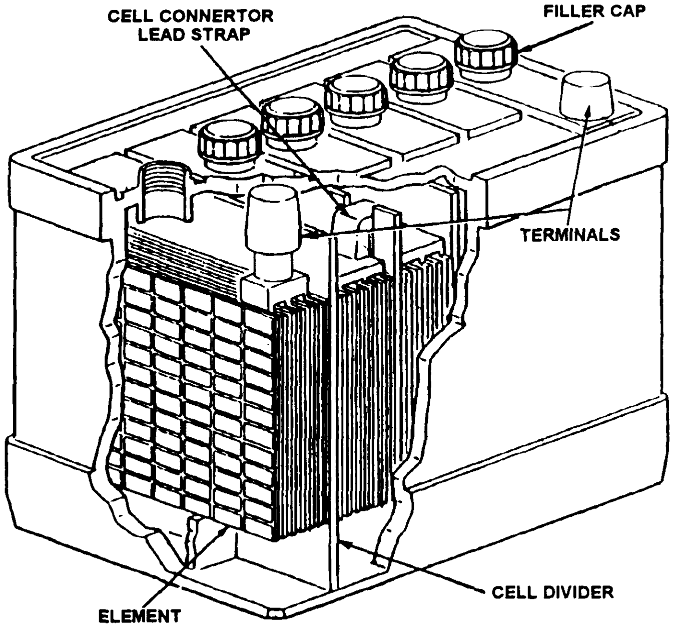


Figure 4-1.—Typical storage battery.

caps and the terminal post protrude from the cover. In other batteries, only the filler caps extend above the cover and the terminal posts extend through the side. The latest design of batteries is the so-called maintenance-free batteries that provide no means of checking the electrolyte or water level.

Battery Capacity

The capacity of a battery is measured in cold cranking amps (CCA). The CCA capacity is equal to the product of the current in amperes and the time in hours during which the battery is supplying this current when cranking a cold engine. The ampere-hour capacity varies inversely with the discharge current. The size of a cell is determined by its ampere-hour capacity. The capacity of a cell depends upon many factors. The most important of these factors are the following: (1) the area of the plates in contact with the electrolyte; (2) the quantity and specific gravity of the electrolyte; (3) the type of separators; (4) the general condition of the battery (degree of sulfating, plates buckled, separators warped, sediment in bottom of cells, etc.); and (5) the final limiting voltage.

CHARGING SYSTEM

The charging system performs two jobs: (1) it recharges the battery and (2) it generates current during operation. The two types of charging systems used on automotive and construction equipment are a dc charging system (fig. 4-2, view A) or an ac charging system (fig. 4-2, view B). Both systems generate an alternating current (at); however, the difference is the way they rectify the ac current to direct current (de) for charging the battery.

Dc Charging System

A dc charging system has a generator and a regulator. The generator supplies the electrical power and rectifies its current mechanically by using commutator bars and brushes. The regulator performs three jobs: (1) it opens and closes the charging circuit, (2) it prevents overcharging of the battery, and (3) it limits the output of the generator to safe rates.

Ac Charging System

An ac charging system has an alternator and a regulator. The alternator is really an ac generator. Like the generator, it produces an ac current but rectifies it electronically, using diodes. Most alternators are more compact than generators of equal output and supply a higher current output at low-engine speeds. The regulator in an ac charging system limits the alternator voltage to a safe, preset value.

Charging System

All charging systems operate in three stages: (1) during starting, the battery supplies all load current; (2)

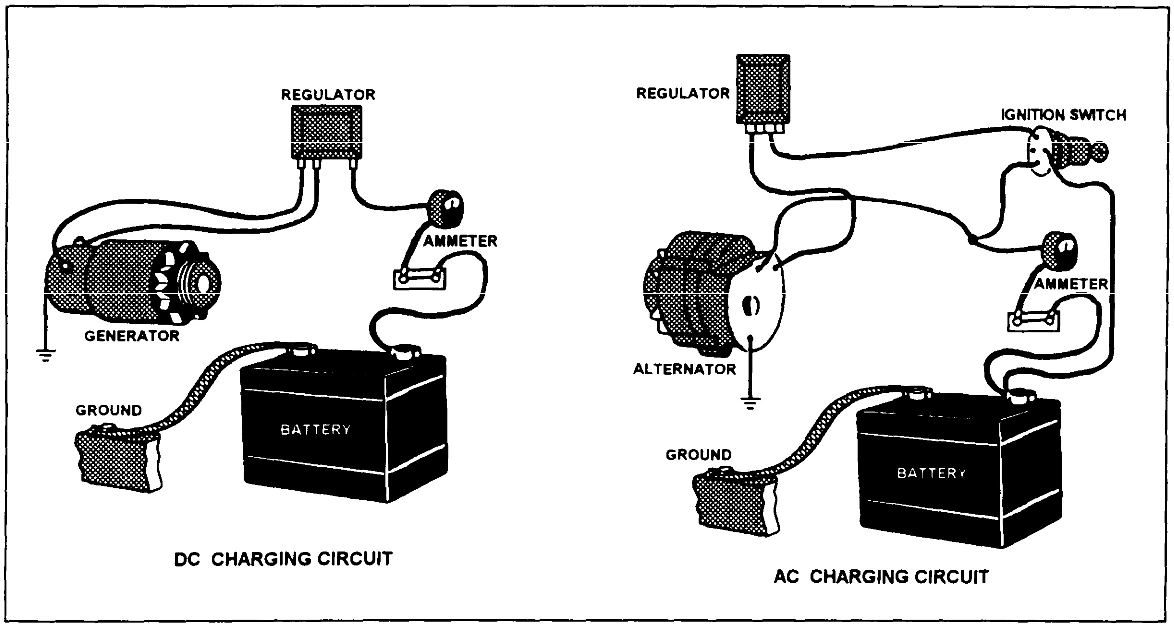


Figure 4-2.—Charging systems.

during peak operation, the battery helps the generator supply current; and (3) during normal operation, the generator supplies all current and recharges the battery.

In both electrical systems, the battery starts the electrical circuit that supplies the spark to start the engine. The engine then drives the generator or alternator that produces current to take over the operation of the ignition, lights, and accessory loads.

The battery also supports the generator or alternator during peak operation when the electrical loads are excessive. But once the engine is started the generator or alternator is the "work horse," providing current to the ignition and accessory circuits. The generator supplies current as long as the engine is at speed and running. When the engine slows down or stops, the battery takes over part or all of the load.

STARTING CIRCUITS

High voltage is often necessary to ensure sufficient starting power due to the high compression ratios of some diesel engines. Three systems are used to increase either the voltage or amperage to accomplish this task These are parallel, series, and series-parallel systems.

Parallel System

An example of a parallel system, as shown in figure 4-3, view A, is two 12-volt, 200-amp batteries are connected from the starter to the positive terminal of one battery to the positive terminal of the second battery. The negative side of the batteries are connected from the ground to the negative terminal from one battery to the negative terminal of second battery. This system provides 12 volts and 400 amps, providing more amperage for starting.

Series System

An example of a series system, as shown in figure 4-3, view B, is two 12 volt, 200-amp batteries are connected from the positive terminal of one battery to the negative terminal of the second battery. The remaining positive terminal is connected to the starter and the remaining negative temninal is connected to the ground. This system provides 24 volt and 200 amps, providing more volts for starting.

Series-Parallel System

A series-parallel system provides a series connection of the batteries for starting and a parallel connection for normal operation. An example of a series-parallel system is when two sets of parallel batteries, as shown in figure 4-3, view C, are connected in series and the negative terminal from one set of the batteries is connected to the positive terminal of the other set. This system provides 24 volts and 800 amps. This combination is used for cranking large construction equipment.

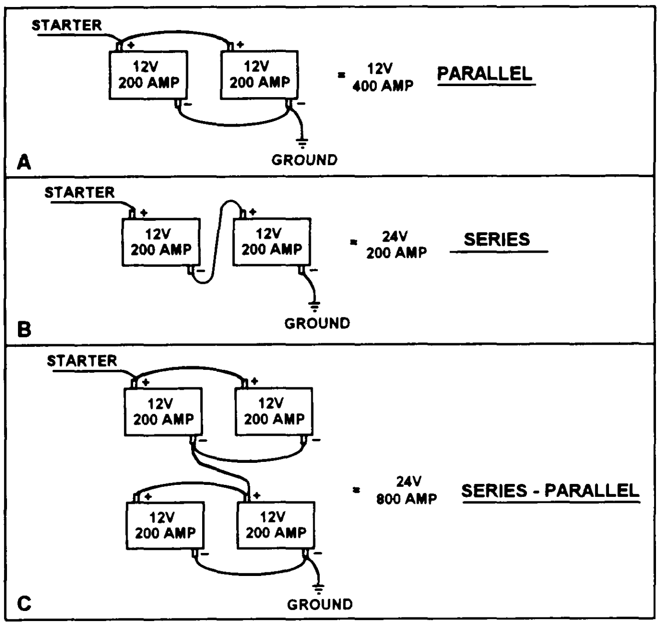


Figure 4-3.—Starting circuits.

CAUTION

Use extreme care when jump starting is required. Hooking up jumper cables from a 24-volt system to a heavy-duty 12-volt system can cause severe battery damage, starter destruction, or even an explosion. If you are unsure of the starting circuit, get help from the mechanic field crew for assistance.

LIGHTING SYSTEM

The lighting system on automotive, construction, and weight-handling equipment includes the lamps and bulbs, clearance lights, side marker lights, reflectors, taillights and brake lights, auxiliary lights, and fuses. Standards for lights on vehicles are outlined in the *Federal Motor Carrier Safety Regulations Pocketbook.*

The manufacturer provides equipment with an electrical system that supports the lighting circuits. Part of your prestart responsibility is to ensure the lights on your equipment work and are clean of dust and dirt. A good rule of thumb to remember is, if a light is on a vehicle, the light must work and be safe.

Lamps and Bulbs

Trucks and buses are lit up like Christmas trees when operating at night. In addition to the headlights and taillights, which are the minimum running lights required bylaw for all vehicles operating at night, trucks and buses must also have clearance and side marker lights. These lights outline the length, height, and width of the vehicle.

Each group of lights in a branch circuit of the lighting system is protected by a fuse or circuit breaker and is provided with a switch. Each light in the group is provided with one or more light bulbs that are rated for the particular circuit.

Light bulbs used in Navy equipment are made to operate on a low-voltage current of 12 or 24 volts, depending upon the voltage of the battery system used. Bulbs are rated as to size by the candlepower of light they produce. They range from small one-half candlepower to large 50-candlepower headlight bulbs. The greater the candlepower of the bulb, the more current it requires when lighted. Bulbs are identified by a number on the base.

Operators are responsible for replacing burned-out bulbs on equipment. Manufacturers have designed bulbs with such a wide variety of designs (fig. 4-4) that it is impossible to list all the bulbs here. A bulb design commonly used has either single or double contacts with nibs to fit bayonet sockets, as shown in figure 4-5. Because of some unique designs, certain bulbs have to be handled with care; for example, quartz bulbs should not be touched by the oil in your skin, because the oil causes the bulb to fail instantly. Because of the unique characteristics of the various bulbs, you should check the operator's manual before replacing any bulbs.

The sealed beam light is actually a large bulb (fig. 4-6). The bulb consists of a lens, filaments, and a glass reflects. Sealed bulbs also have various designs; some have filaments designed for high beam, some with one filament designed for low beam, and bulbs with two filaments designed for high and low beam.

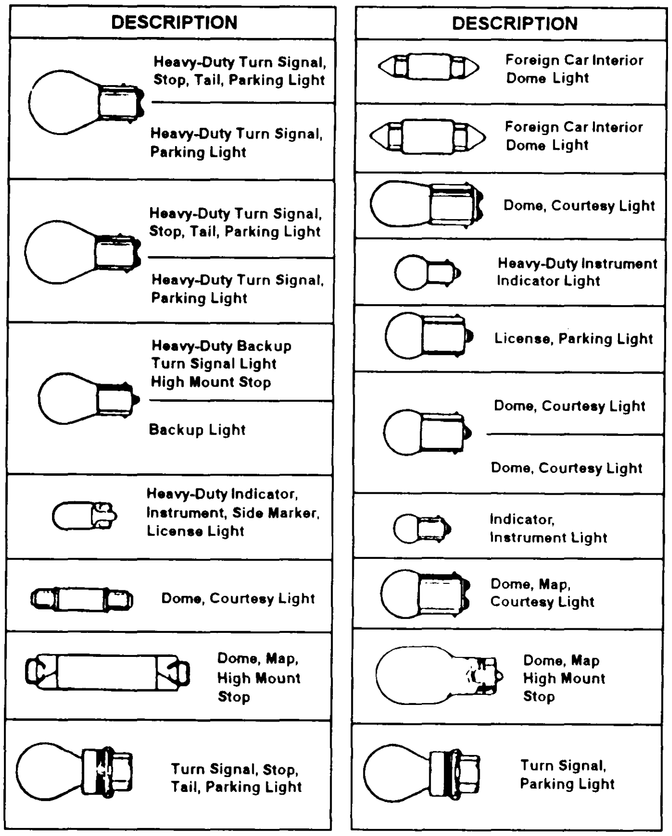

DESCRIPTION
Heavy-Duty Turn Signal, Stop, Tail, Parking Light
Heavy-Duty Turn Signal, Parking Light
Heavy-Duty Turn Signal, Stop, Tail, Parking Light
Heavy-Duty Turn Signal, Parking Light
Heavy-Duty Backup Turn Signal Light High Mount Stop
Backup Light
Heavy-Duty Indicator, Instrument, Side Marker, License Light
Dome, Courtesy Light
Dome, Map, High Mount Stop
Turn Signal, Stop, Tail, Parking Light
DESCRIPTION
Foreign Car Interior Dome Light
Foreign Car Interior Dome Light
Dome, Courtesy Light
Heavy-Duty Instrument Indicator Light
License, Parking Light
Dome, Courtesy Light
Dome, Courtesy Light
Indicator, Instrument Light
Dome, Map, Courtesy Light
Dome, Map High Mount Stop
Turn Signal, Parking Light

Figure 4-4.—Bulbs.

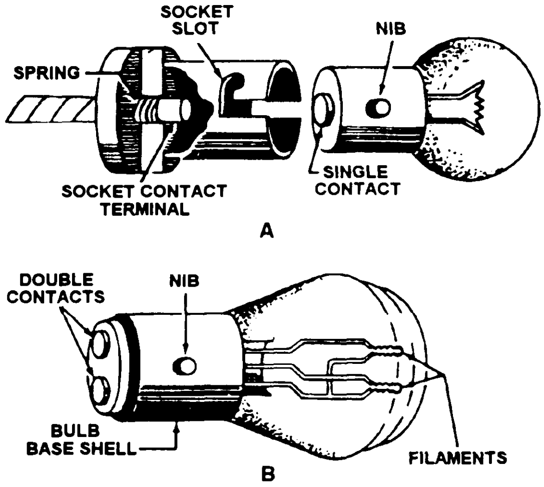

SOCKET SLOT
NIB
SPRING
SOCKET CONTACT TERMINAL
SINGLE CONTACT
A
DOUBLE CONTACTS
NIB
BULB BASE SHELL
FILAMENTS
B

Figure 4-5.—Single- and double-contact bulbs.

Clearance Lights

Clearance lights detail the maximum width of the vehicle, not necessarily its height as the word ***clearance*** implies. These lights highlight the protruding unlighted front and rear corners of the vehicle that are subject to collision with other vehicles or persons, not the top of the vehicle. Clearance lights should be mounted at a height best suited to allow them to be readily seen from a minimum distance of 500 feet from the vehicle. The clearance light on the front of a vehicle should be amber in color, and those facing the rear red. Some state regulations require that larger vehicles have **identification**

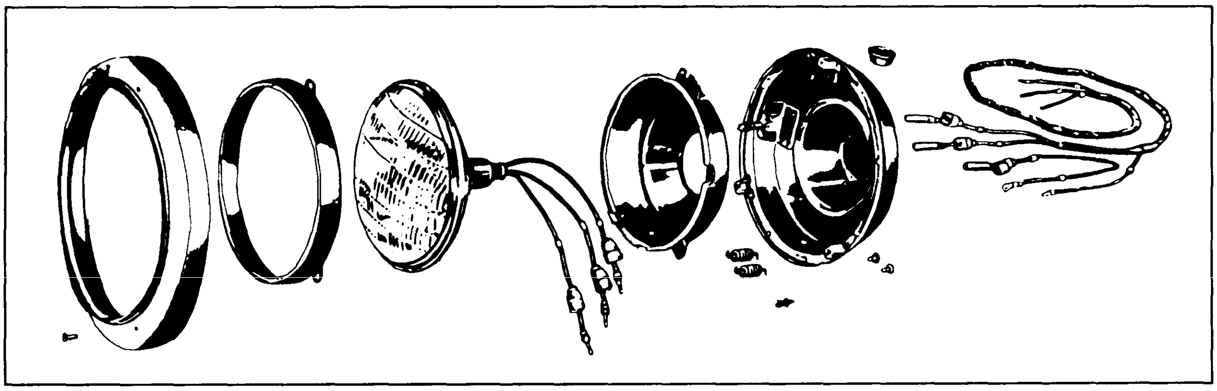


Figure 4-6.—Typical sealed beam headlight assembly.

lights that outlines the height of the vehicle. Some vehicles have a separate switch for the clearance lights. When you are operating a vehicle at night with clearance lights, do not forget to turn them on.

Side Marker Lights

Side marker lights are similar to clearance lights; however; they indicate the full-overall length of the vehicle as viewed from the side. They must also be visible from a minimum distance of 500 feet from the vehicle. Side marker lights, mounted near the front of the vehicle, are also amber and those near the rear are red.

Reflectors

Reflectors (except for those used in the lights) are used as an additional safety precaution in case lights burn out or are broken. When mounting reflectors, ensure they are between 24 to 42 inches above the ground.

Taillights and Brake Lights

All taillights must show red and be visible from at least 500 feet from the rear of the vehicle. The taillight lens should be replaced if it is not red or contains a dot of another color or if it is cracked, broken, or does not fit tightly. A brake light is usually combined with the taillight by using a double-contact, double-filament bulb; however, it maybe a separate light. Stop lights must light up immediately when the brake pedal is depressed; that is, at the beginning of the downward action of the brake pedal. Brake lights are a safety-required item and they must be operational at all times. Burnt-out or weak lights should be documented and repaired before operating your vehicle or piece of equipment.

Auxiliary Lights

Lights that can be turned on or off for the convenience or safety of the driver or passengers are called auxiliary lights. These lights are wired to be turned on and off independently, and not with the headlights. When performing your prestart operation, you should ensure all auxiliary lights work.

SPOTLIGHTS.— Spotlights are often mounted on construction equipment and weight-handling equipment. When conducting prestart operations, always make sure the spot-lights work because you never know when you will encounter conditions or situations requiring their use.

BACKUP LIGHTS.— Backup lights are accessories for many vehicles. They may be mounted singly or as a pair, one on each side. Backup lights lenses must be colorless and must turnoff automatically when the vehicle is moving forward. Backup lights may also be connected to a audible signal. A backup light must be aimed to strike the road at a distance that does not exceed 25 feet from the rear of the vehicle.

PARKING LIGHTS.— Parking lights have amber or white lenses and are located on the front of the vehicle. They turn on and off with the same switch as the taillights.

Fuses

Fuses are safety devices placed in electrical circuits to protect wires and electrical units from a heavy flow of current. Each circuit, or at least each individual electrical system, is provided with a fuse that has an ampere rating for the maximum current required to operate the unit.

The fuse element is made from a metal that has a low-melting point and is the weakest point in the electrical circuit. In case of a short circuit or other trouble, the fuse burns out first and this opens the circuit just as a switch would do. Visual examination of a burned-out fuse usually provides a quick indication of the problem. A discolored sight glass indicates the circuit has a short either in the wiring or one of its components. If the glass is clear, the problem may be an overload in the circuit.

When replacing a fuse, you should ensure that it has a rating equal to the one burned out. Also, ensure that the malfunction that caused the failure has been determined and repaired.

GAUGES

Just because everything checks out okay during the prestart operation does not mean it will stay that way throughout the workday. You must continually monitor certain conditions, such as water temperature, oil pressure, and so forth, to ensure the equipment is running correctly. You monitor them by watching the indicator (warning lights or gauges) on your equipment. On equipment, you may see an analog type of gauge (fig. 4-7) or color-coded indicators, as shown in figure 4-8.

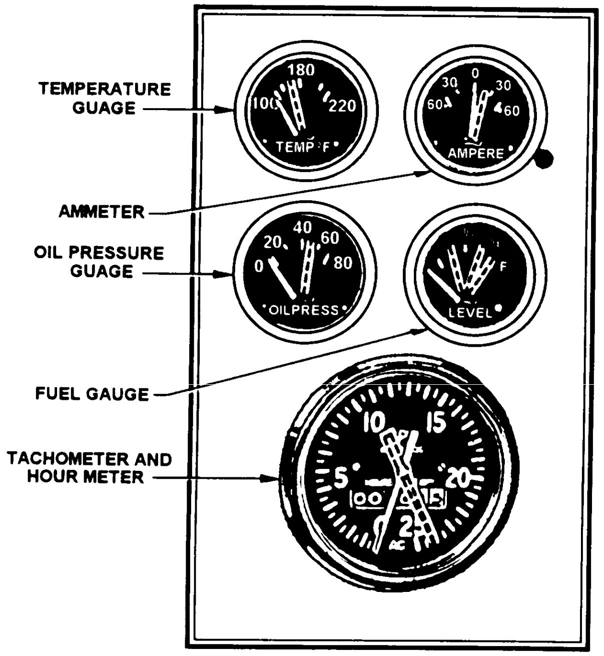

TEMPERATURE GUAGE
AMMETER
OIL PRESSURE GUAGE
FUEL GAUGE
TACHOMETER AND HOUR METER
180
100
220
TEMP °F
30
0
30
60
60
AMPERE
20
40
60
0
80
OILPRESS
F
LEVEL
10
15
5
20

Figure 4-7.—Analog gauges.

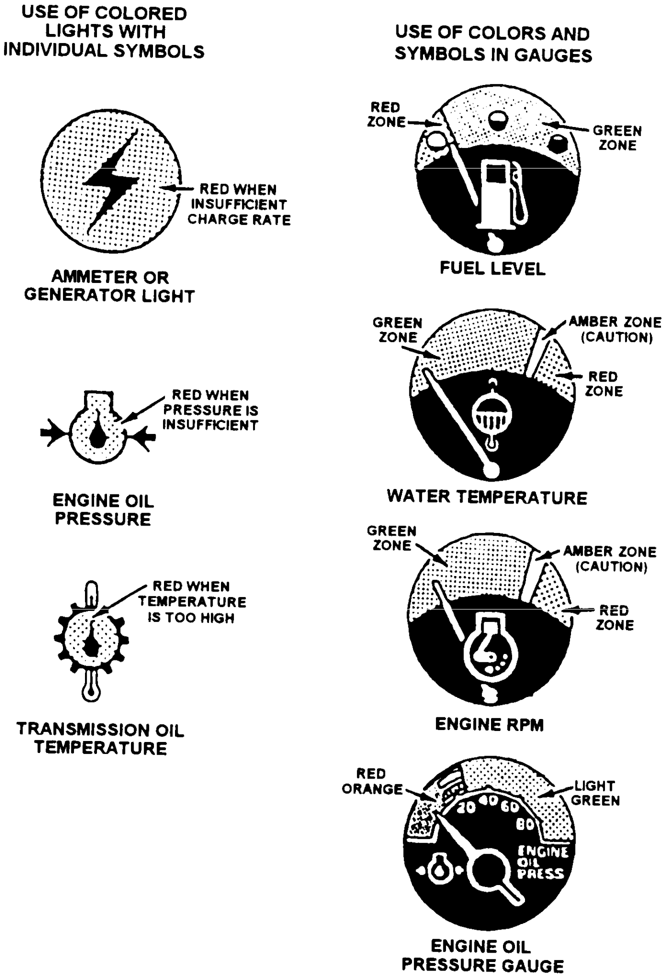

USE OF COLORED LIGHTS WITH INDIVIDUAL SYMBOLS
USE OF COLORS AND SYMBOLS IN GAUGES
RED ZONE
GREEN ZONE
RED WHEN INSUFFICIENT CHARGE RATE
FUEL LEVEL
AMMETER OR GENERATOR LIGHT
GREEN ZONE
AMBER ZONE (CAUTION)
RED ZONE
RED WHEN PRESSURE IS INSUFFICIENT
ENGINE OIL PRESSURE
WATER TEMPERATURE
GREEN ZONE
AMBER ZONE (CAUTION)
RED ZONE
RED WHEN TEMPERATURE IS TOO HIGH
TRANSMISSION OIL TEMPERATURE
ENGINE RPM
RED ORANGE
LIGHT GREEN
20
40
60
80
ENGINE OIL PRESS
ENGINE OIL PRESSURE GAUGE

Figure 4-8.-Color-coded gauges.

Water Temperature Gauge

When operating a piece of equipment, you must monitor the water or coolant temperature gauge. If your machine has an analog type of gauge (fig. 4-7), you must know the correct operating temperature. Refer to the operator's manual to determine the operating temperature. Anytime the temperature reading on the gauge starts to rise, stop and determine the reason. Do not wait until the gauge is in the red zone to investigate.

WARNING

Use extreme caution when removing a hot radiator cap. Steam coming from the radiator will cause severe burns.

CAUTION

Do not add cold water to a hot engine when it is not running. Rapid cooling of an overheated engine will cause severe damage to the cylinder head and block. To cool an overheated engine down, leave the engine running and add water slowly. Watch for the steam that may be produced when adding water. Should a radiator hose burst, secure the engine before the temperature gets too high.

Oil Pressure Gauge

The oil pressure indicator is one of, if not, the most important gauges to watch. Every vehicle or equipment has an oil pressure warning light or a gauge. Should you start to lose oil pressure and the warning light comes on, secure the engine immediately. Operating equipment without proper oil pressure causes severe damage to the engine.

Check the oil level in the engine. If the oil level is low, add oil until it is at the proper level. Start the engine; if oil pressure does not register on the gauge or the light stays on for 30 seconds, secure the engine. Then document and report the problem.

Should the oil level be correct and no pressure registers on the gauge or the warning light stays on, secure the engine. Then document and report the problem.

NOTE: A rule of thumb is that after starting an engine, the oil pressure gauge should show 30 pounds of oil pressure after the engine runs for 30 seconds. Should the oil level be correct but no pressure registers on the gauge, secure the engine. Then document and report the problem.

Air Pressure Gauge

There is an air pressure gauge on each vehicle equipped with an air-brake system. The air pressure must be maintained within a range of 100 pounds per square inch (psi) to 120 psi. A warning light or buzzer should come on if the air pressure drops below 60 psi. If there is a rapid loss of air pressure, an air unit may have burst. A slow leak may sometimes be repaired by tightening a fitting.

WARNING

Do not operate any equipment with air brakes if there is an air leak.

With the engine at operating rpm, the air pressure system should build from 85 to 100 psi within 45 seconds in dual-air systems. In single-air systems (pre-1975), the pressure should build up from 50 to 90 psi within 3 minutes.

Hydraulic Pressure Gauge

Most types of construction equipment are equipped with hydraulic pressure guages. When operating this equipment, you must watch for leaks. Consult the operator's manual for the pressure at which the equipment should be operated. Should the pressure not reach the operating range or should you detect a leak, be sure to document and report either or both.

Hydraulic Temperature Gauge

Most types of construction equipment are also equipped with hydraulic temperature gauges. In most cases, if the hydraulic temperature exceeds the recommended temperature, it is because the fluid level is 100 low.

Should the fluid level be correct and the equipment overheats, you are overworking the hydraulic system. Stop your machine and check the hydraulic fluid level. Be careful because the hydraulic fluid is hot and the hydraulic system may be pressurized. If the fluid level is normal, let the machine sit at idle to cool the hydraulics.

Fuel Level Gauge

When prestart inspecting a piece of equipment, you should visually check the fuel. During the day, watch the fuel gauge to ensure it shows a slow depletion of fuel. Should the fuel gauge not move in a reasonable amount of time, assume the fuel gauge is broken. In this case, check the fuel visually from time to time to ensure that you do not run out of fuel.

HYDRAULIC SYSTEMS

Hydraulic systems on equipment are used to transmit power for steering and controlling the operation of mechanical components. The basic components of a hydraulic system (fig. 4-9) consist of a reservoir, strainer and falters, pump, control valves, hydraulic cylinders, hoses, couplers, accumulators, and on some systems, a hydraulic motor.

HYDRAULIC RESERVOIR

The hydraulic reservoir is the fluid storehouse for the hydraulic system. It contains enough fluid to supply the normal operating needs of the hydraulic system and an additional supply to replace fluid lost through minor leaks. Additionally, the reservoir allows the settling of any impurities and separation of air from the fluid before reuse in the system.

The basic hydraulic reservoir (fig. 4-10) has a space above the fluid even when they are full. This space allows the fluid to foam, and thus purge itself of air

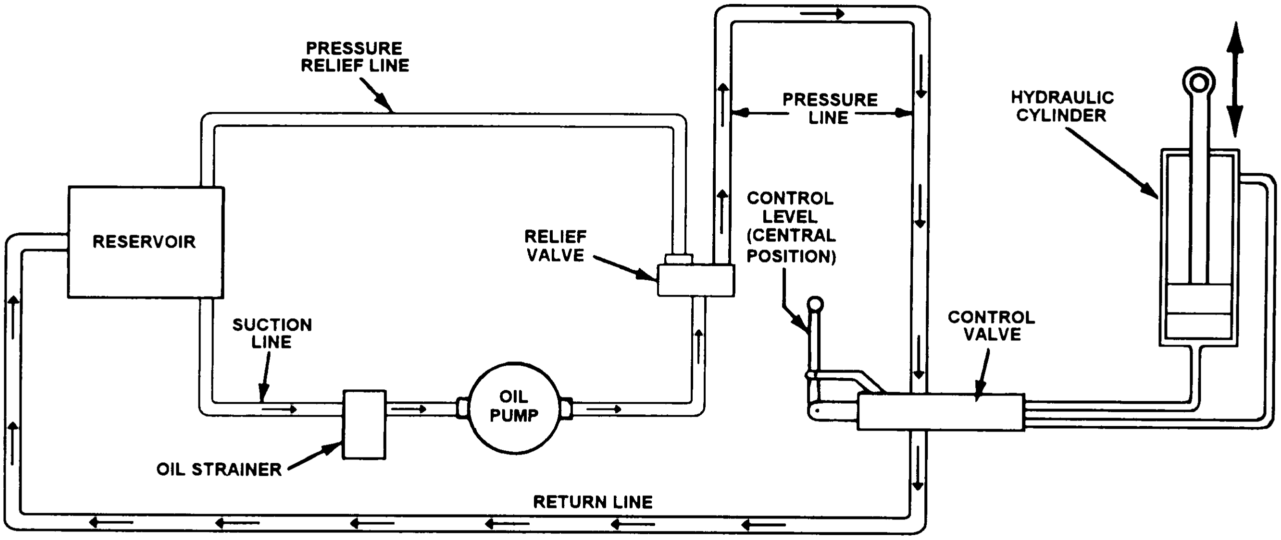

PRESSURE RELIEF LINE
PRESSURE LINE
HYDRAULIC CYLINDER
RESERVOIR
RELIEF VALVE
CONTROL LEVEL (CENTRAL POSITION)
SUCTION LINE
OIL PUMP
CONTROL VALVE
OIL STRAINER
RETURN LINE

Figure 4-9.-Basic hydraulic system.

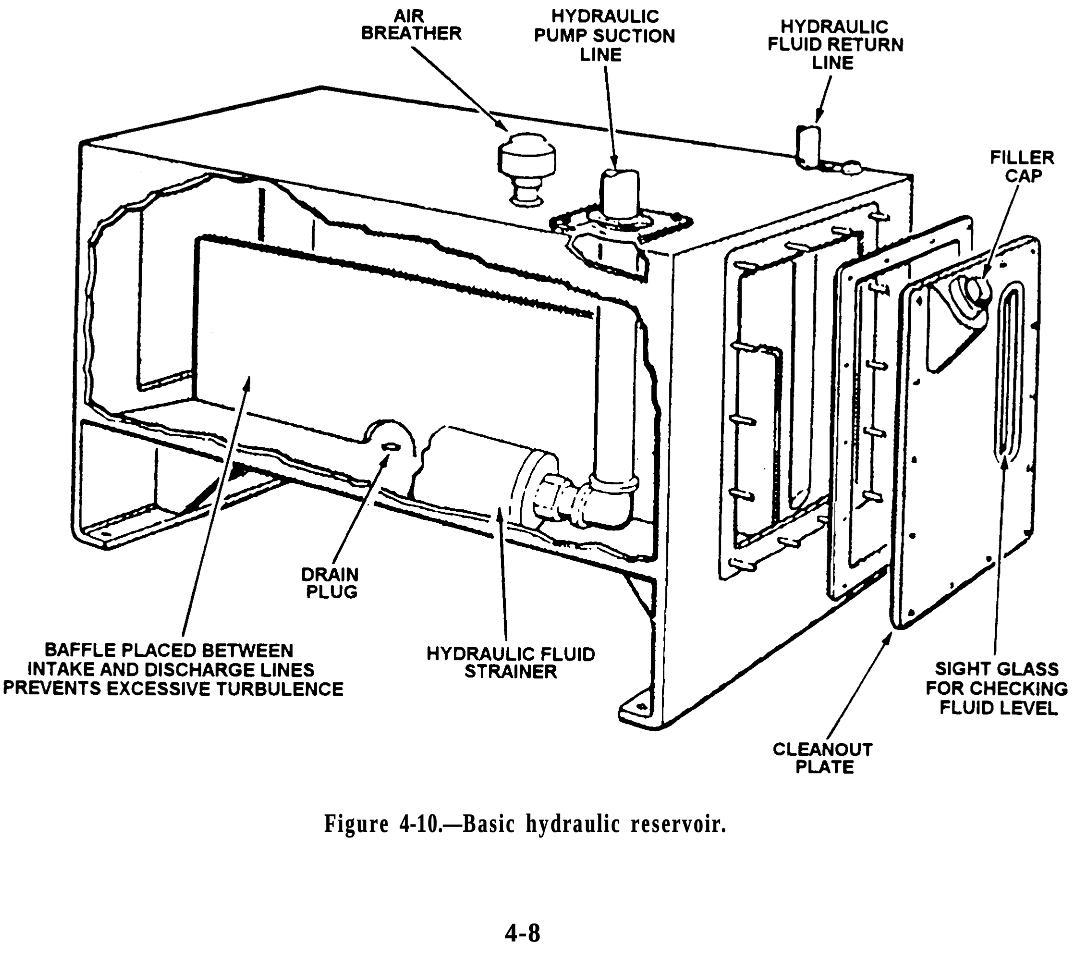

AIR BREATHER
HYDRAULIC PUMP SUCTION LINE
HYDRAULIC FLUID RETURN LINE
FILLER CAP
DRAIN PLUG
BAFFLE PLACED BETWEEN INTAKE AND DISCHARGE LINES PREVENTS EXCESSIVE TURBULENCE
HYDRAULIC FLUID STRAINER
SIGHT GLASS FOR CHECKING FLUID LEVEL
CLEANOUT PLATE

Figure 4-10.—Basic hydraulic reservoir.

bubbles that normally occur as the fluid flows from the reservoir, through the system, and back to the reservoir.

The air vent allows the air to be drawn in and pushed out of the reservoir by the ever-changing fluid level. An air filter is attached to the air vent to prevent drawing atmospheric dust into the system.

Because it is essential that the fluid in the reservoir be kept at the correct level at all times, the sight gauge is provided to allow the normal fluid level to always be seen The baffle plate segregates the outlet fluid from the inlet. This allows the fluid time to dissipate air bubbles, contaminants to settle, and the return fluid to cool before it is picked up by the pump.

The proper hydraulic fluid level must be maintained. In some systems low fluid level causes overheating because the fluid does not have enough time to cool in the reservoir before it gas back into the pump. Also, some systems will not work at all because the fluid is so low in the reservoir that air gets into the pump.

Before adding hydraulic fluid, know what type to use and make sure it is clean. Clean around the filler cap or tube so there is less chance that dirt can get into the system.

STRAINERS AND FILTERS

Hydraulic systems have a strainer and one or more filters that remove the impurities that would eventually contaminate the hydraulic fluid. The strainer is normally located in the reservoir or in the inlet line to the pump. The filter is normally located so only a small amount of fluid is lost when the element is changed. The falter is equipped with a valve that allows the fluid to bypass the filter element should it become clogged. The falter element is usually of the paper cartridge, canister, or edge type and is similar to those used in engine lubrication systems. Regular filter maintenance, performed by the mechanics, is necessary to prevent contaminated fluid from being recirculated in the system.

HYDRAULIC PUMPS

The hydraulic pump creates the flow of fluid within the hydraulic system. The pressure in a hydraulic system is caused by a restriction placed in the path of the fluid as it leaves the pump. Because of the resulting mechanical drive and positive displacement, the pump merely moves the fluid regardless of the restriction. When enough pressure is built up, movement of the restriction occurs or a relief valve placed in the system opens, allowing the fluid to return to the reservoir or the suction side of the pump.

When the pump operates, hydraulic fluid is trapped between the gear teeth and the pump housing and is carried to the outlet side of the pump. As the teeth mesh, a seal is freed by the mating surfaces that prevent the oil from leaking back to the inlet side of the pump. The sealing action causes the oil to be forced out of the pump and into the system.

CONTROL VALVES

Control valves are valves accessible to the operator for directing the flow of fluid within the system to operate the machine or its attachment. By skillful use of the control valves, the operator can regulate the speed and operation of the hydraulic cylinders.

NOTE: Hydraulic controls should be operated smoothly to eliminate the jerking motion that causes rapid wear and failure of the mechanical parts of the machine.

HYDRAULIC CYLINDERS

Hydraulic cylinders are used to transmit motion in relation to the volume of fluid directed into the cylinder. The force created by the cylinder is determined by the pressure of the fluid and the area of the piston contacted by the fluid. Thus the larger the piston, the more force generated.

Hydraulic cylinders used on heavy equipment are either single- or double-acting cylinders.

Single-Acting Cylinders

Single-acting cylinders, similar to the one shown in figure 4-11, view A, are used to exert force in only one direction. This means the weight or resistance moved must be located so it causes the cylinder to return to its original position when pressure is relieved from the piston. A common use of this type of cylinder is in a hydraulic jack.

Double-Acting Cylinders

Double-acting cylinders are used on equipment where force is needed in two directions. Unlike the single-acting cylinder, the double-acting cylinder contains seals at both ends of the piston where the piston rod passes through the end of the cylinder. With the use of this cylinder, fluid can be directed to either side of the piston and cause the piston rod to extend or retract under pressure. The double-acting cylinder shown in figure 4-11, view B, is called an unbalanced cylinder. This means that the cylinder can exert more force in one direction than in the other. This is due to the piston rod preventing fluid from acting on the full area of the piston on one side.

NOTE: Wipe off all foreign material from hydraulic rams with a clean rag during pre- and post-operations to prevent damaging seals and wiper seals. Before you store equipment, a very important procedure to remember is that the exposed hydraulic rams on the equipment and attachments should be coated in grease. This action protects the surface of the hydraulic ram and is critical in storage locations where corrosive environmental conditions, such as salty air, strong winds, or blowing sand, exist.

Remember: Wipe off the grease before using the equipment when it is removed from storage.

FLEXIBLE HOSES

Flexible hoses are used in a hydraulic system to allow movement between mechanical parts of the

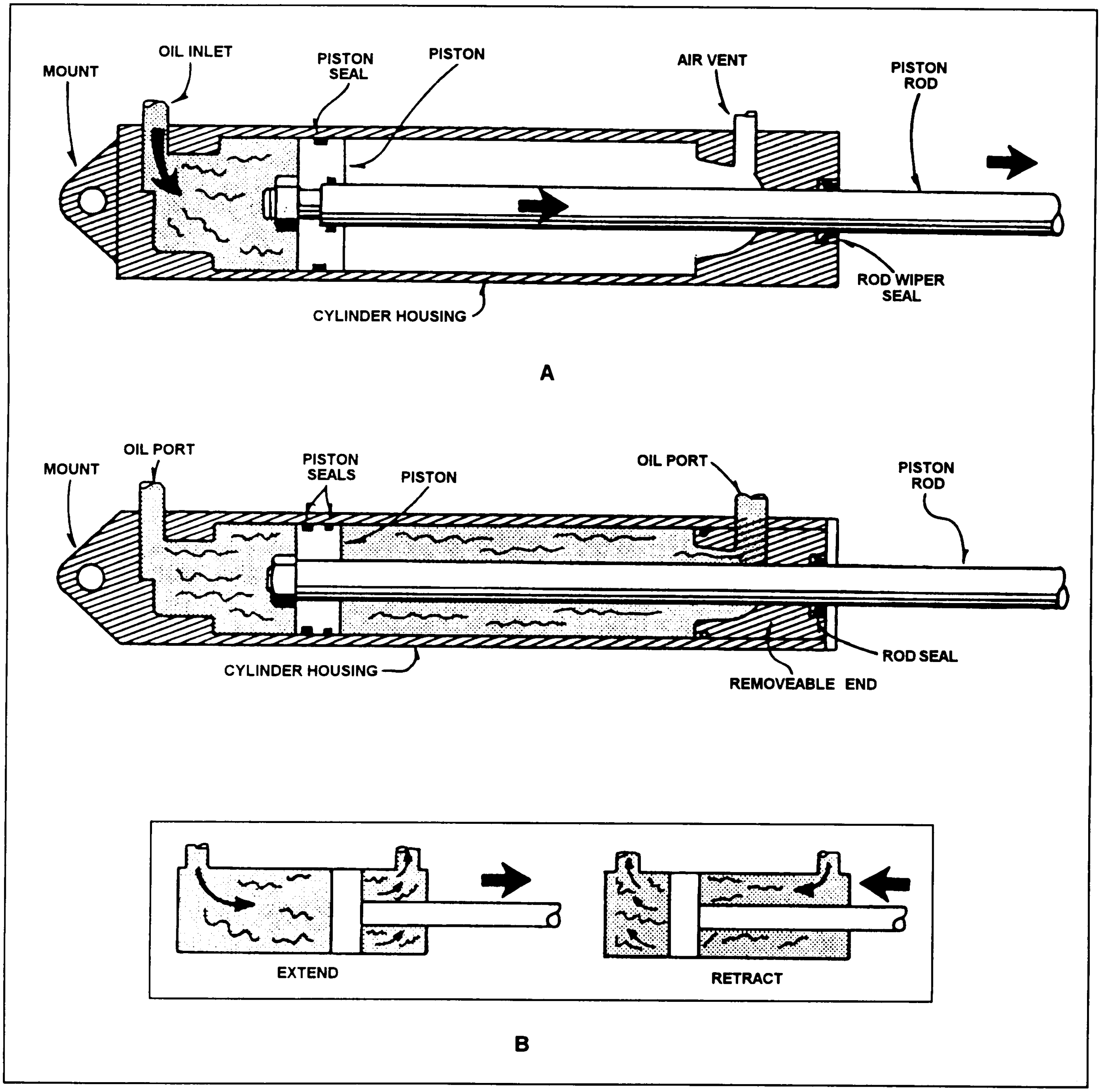

MOUNT
OIL INLET
PISTON SEAL
PISTON
AIR VENT
PISTON ROD
ROD WIPER SEAL
CYLINDER HOUSING
A
MOUNT
OIL PORT
PISTON SEALS
PISTON
OIL PORT
PISTON ROD
ROD SEAL
REMOVEABLE END
CYLINDER HOUSING
EXTEND
RETRACT
B

Figure 4-11.—(A) Single- and (B) double-acting hydraulic cylinders.

equipment. Hoses are manufactured in layers (fig. 4-12). The inner layer is made of synthetic materials that resist deterioration from the fluid in the system. The middle layer or layers are made of either fabric or rubber for low-pressure systems or wire braid for high-pressure applications. These layers give the hose its strength.

Part of your pre- and post-operational inspections is to inspect hoses for cracking or splitting, pinhole leaks, improper hose length, rubbing, heat, twisting, and so forth. Any problems with hydraulic hoses should be repaired before use.

QUICK-DISCONNECT COUPLERS

Quick-disconnect couplers (fig. 4-13) are used where hydraulic lines must be connected or disconnected frequently; for example, in the NCF, quick-disconnect couplers used on front-end loaders allow quick changing of loader buckets, backhoes, and forklift attachments.

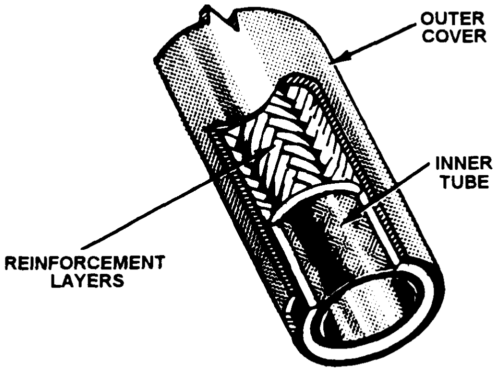


Figure 4-12.—Hydraulic hose construction.

The quick-disconnect couplers are self-sealing devices that accomplish the work of two shutoff valves and a tube coupler. They are easy to use and keep hydraulic fluid loss at a minimum. More importantly, you do not have to drain or bleed the system each time a hookup is made.

Quick-disconnect couplers consist of two halves: the body contains a spring-loaded poppet or seal, while the other half is inserted to open the poppet when the two halves are connected. A locking device holds the two halves and seals them.

When quick-disconnect couplers are disconnected on attachments, you must remember that it is *very important* that dust plugs are inserted in the coupler ports. If dust plugs are unavailable, a common practice is to use a plastic bag to wrap the couplers in for protection from foreign matter.

CAUTION

Hydraulic systems can create up to 3,000 pounds of pressure per square inch and the fluids may reach temperatures above 200°F. Wear protective gloves and use extreme care when disconnecting and reconnecting quick-disconnect couplers.

ACCUMULATORS

Accumulators are sometimes placed in a hydraulic system to absorb shock. These are frequently used on

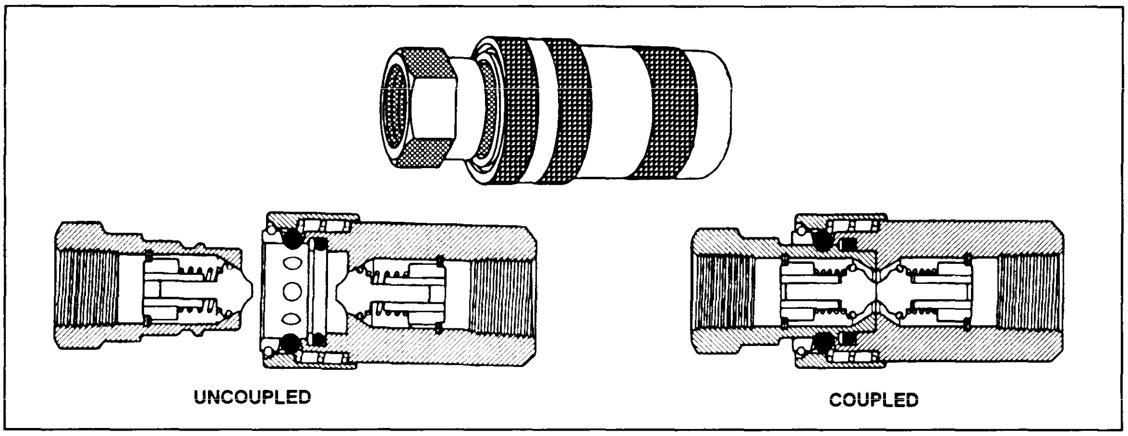


Figure 4-13.—Quick-disconnect couplers.

tracked front-end loaders and other equipment containing hydraulic systems that are subjected to severe shock.

The accumulator is a large cylinder that contains compressed gas or a coil spring separated from the hydraulic fluid by a piston, rubber bladder, or diaphragm. When a heavy shock is placed on the hydraulic system, fluid enters the cylinder and causes the gas or spring to compress. Once the shock load stabilizes within the hydraulic system, the fluid is forced back to the operating portion of the system.

HYDRAULIC MOTORS

The hydraulic motor provides power to winches on cranes, drives conveyors on ditching machines, and is used in other applications where mechanical drives are impractical.

The hydraulic motor is turned by fluid under pressure supplied by the pump. The fluid enters the housing and acts on the rotating members. It then discharges and returns to the reservoir or pump.

CHAPTER 5

RULES OF THE ROAD

Operators of Navy vehicles are expected to practice "*courtesy on the road*" at all times toward other drivers as well as toward pedestrians. Courtesy distinguishes the efficient and safe driver from a poor driver. The driver who practices courtesy on the road is helping prevent mishaps with other vehicles and injuries to pedestrians. Road courtesies are part of the basic "rules of the road" that include procedures for driving under normal, hazardous, and special conditions.

Any information in this chapter is not to be construed as nullifying or superseding regulations or laws of another country, state, or municipal authority. For more information, see your license examiner or the *Navy Driver's Handbook*, NAVFAC MO-403; *Federal Motor Carrier Safety Regulations Pocketbook*, ORS-7A; and local instructions.

DEFENSIVE DRIVING

You have probably seen many examples of discourtesy on the road. Common traits often displayed by discourteous drivers include the following: impatience, road hogging, and excessive speed. A person with such characteristics may be knowledgeable about driving, but it takes more than knowledge when SAFETY is a concern. To achieve a good safety record, you must be a "*defensive driver*" at all times.

A defensive driver makes allowance for lack of skill and experience by other drivers and also learns to recognize mishap-producing situations far enough in advance to avoid them. The defensive driver yields to other drivers and yields the right-of-way, rather than risk a mishap. Defensive drivers understand their responsibilities and show proper respect for driving regulations and the rights of others.

As a professional Equipment Operator (EO), you should demonstrate a businesslike and courteous attitude, alert posture, and skilled performance when behind the wheel. You should handle the vehicle controls easily and smoothly and always be aware of the position of your vehicle in relation to other traffic. If you keep a safe distance from the vehicle ahead and obey the traffic control signals of the individual directing traffic, you will not have to abuse the brakes on your vehicle. You should always keep your vehicle in the proper lane, signal right and left turns in advance, and rarely have to make sudden stops.

AVOIDING REAR-END COLLISIONS

Most of the areas you will work in are considered industrial. In these areas, traffic is heavy most of the time. The size of the vehicles, combined with congestion of traffic, results in frequent rear-end collisions. Here are some precautions you can take to avoid rear-ending someone:

- Be sure you have enough room to stop at traffic control points.
- Keep enough distance between you and the vehicle in front of you at stops so that you can see their brake lights and taillights.
- Watch the movement of vehicles that are two and three vehicles ahead of you.

Precautions you can take to avoid someone rear-ending you are as follows:

- Ensure your brake and turn signals work properly.
- Use your mirrors and be alert to what is happening behind you.
- Do not stop suddenly if you can avoid it.
- Signal well in advance for stops, lane changes, and turns.
- Drive with the flow of traffic. Driving too slow can be as dangerous as driving too fast.

SPEED LIMITS

Speed is the cause of many mishaps. To avoid being fined or involved in an mishap, *obey the speed limits.*

NOTE: Speed limits indicate how fast you may drive under good conditions. Several statutes are in the law books covering speed limits; however, you are responsible for adjusting your speed to weather and road conditions.

CORRECTING A SKID

If a vehicle SKIDS, steer in the direction of the skid to regain control. Sometimes light pressure on the accelerator may help bring the vehicle under control. Do NOT apply brakes, because this may lock the wheels. Brakes, when used, should be applied lightly and released quickly if skidding begins. The way to correct for skidding is shown in figure 5-1.

DRIVING UNDER NORMAL CONDITIONS

Normal driving conditions are conditions encountered on a day-to-day basis that may cause mishaps. Be aware of these conditions and drive in a defensive driving mode at all times.

TURNING

Some mishaps are caused by drivers who do not make turns correctly. To make a turn safely, follow these guidelines:

1. Never make last minute turns.
2. Be aware of what is going on around you. Check your mirrors (rear view and sides).
3. When planning to make a turn at an intersection, move into the correct turning lane prior to approaching the intersection. For a right turn, the correct lane is the one next to the right edge of the roadway. Should you be on a two-lane road with traffic in both directions, a left-hand turn should be approached from the right half of the roadway nearest the center line.
4. Signal at least 100 feet before you turn.
5. Make your turn at a safe speed.
6. Stay in the proper lane when turning. Vehicles coming from the opposite direction have the right-of-way.
7. Finish your turn in the proper lane. (See fig. 5-2.)

PASSING

When overtaking and passing other vehicles on the road, observe the common rules of passing. Use extreme caution whenever passing a vehicle, because the view immediately beyond the other vehicle is blocked on that side. The greater the speed of the vehicle ahead, the more road space and time is required to overtake and pass the vehicle.

The following are restrictions for overtaking and passing:

1. Do not pass to the right of another vehicle, except on multiple-lane, divided highways (more than two lanes of traffic moving in one direction) and **only then if passing is permitted;** use extreme caution in such instances.
2. Do not pass at an intersection or railroad crossing.
3. Do not pass on a hill or curve, except on multiple-lane, divided highways.
4. Do not pass a vehicle signaling to turn or to move into your lane of traffic, or one that has started to overtake and pass another vehicle.
5. Do not pass if the center line of the road is solid on your side.
6. Do not pass if the highway is divided by two solid lines.
7. Do not pass if the single center line is solid.

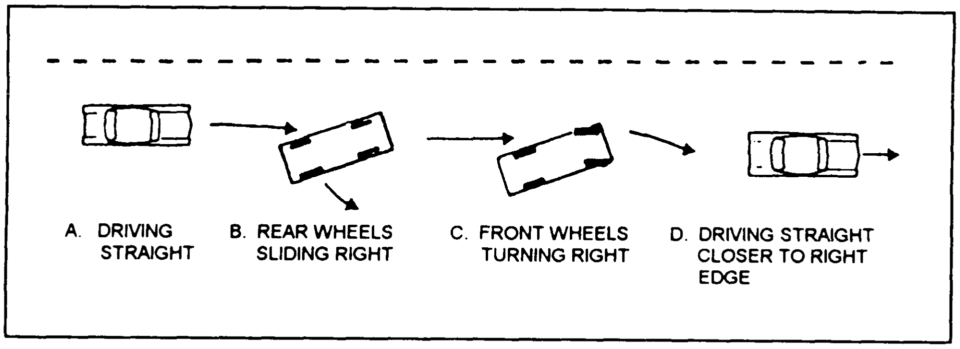
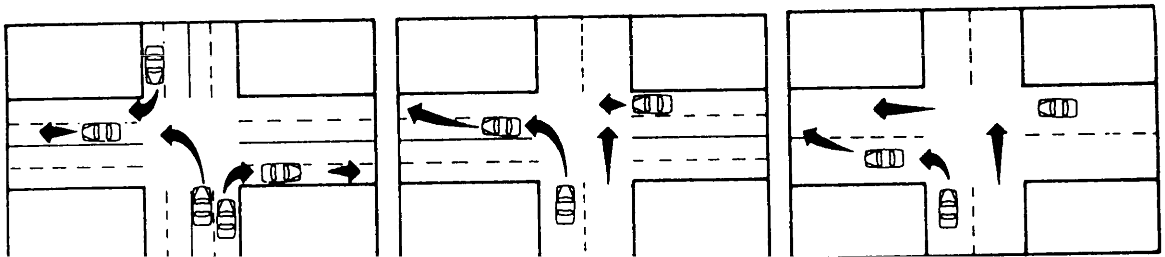

A. DRIVING STRAIGHT
B. REAR WHEELS SLIDING RIGHT
C. FRONT WHEELS TURNING RIGHT
D. DRIVING STRAIGHT CLOSER TO RIGHT EDGE

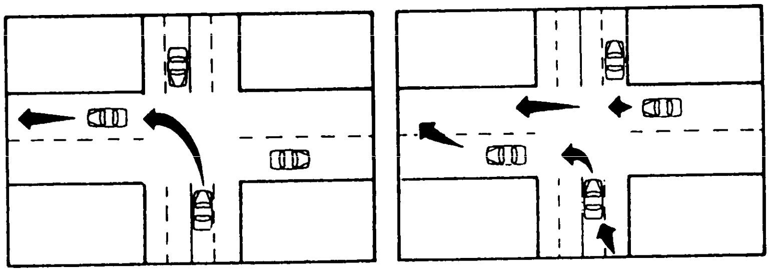
Figure 5-1.-Correcting a skid.



A. LEFT AND RIGHT TURNS

B. LEFT FROM ONE-WAY INTO TWO-WAY ROADS

C. LEFT FROM ONE-WAY INTO ONE-WAY ROADS



D. LEFT FROM TWO-WAY INTO TWO-WAY ROADS

E. LEFT FROM TWO-WAY INTO ONE-WAY ROADS

Figure 5-2.—Proper turning.

PARKING

When parking in the parking lane on a street, you should move as faraway from traffic as possible. Where there is a curb, pull close to it; you must not park more than 1 foot away. Always park on the right side of the roadway, unless it is a one-way street.

Make sure your vehicle cannot roll. Set the parking brake, and shift to park with an automatic transmission or reverse with a manual transmission. Turn the front wheels to keep your vehicle from rolling into the street. (See fig. 5-3.) Before you exit your vehicle, look over your shoulder to the rear to make sure the way is clear.

BACKING UP

Backing into other vehicles, objects, power lines, or people is considered negligence on the part of the operator. To avoid backing mishaps, you should use the common practices that are used in the NCF. These practices are as follows:

1. Blow the horn at least twice before reversing the vehicle. This alerts personnel in the surrounding area that a vehicle is preparing to backup.
2. Exit the vehicle and survey the area for items you cannot see from the cab of a truck or equipment before backing in an unfamiliar area. Check the following: low power lines, fire hydrants, warning poles, guy wires, parked vehicles, and other obstacles.
3. Use a backup guide (signal person). The backup guide signals you from the rear of your vehicle as you perform your backing operations. Survey the area and communicate with the backup guide so you both have an understanding of the backing operation.

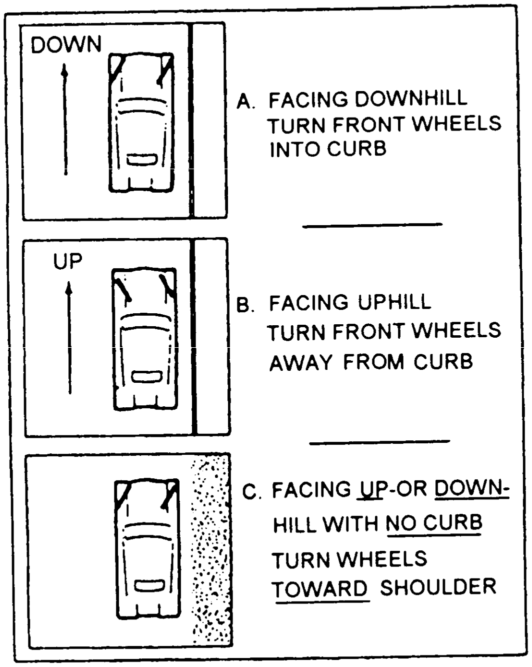

DOWN
A. FACING DOWNHILL TURN FRONT WHEELS INTO CURB
UP
B. FACING UPHILL TURN FRONT WHEELS AWAY FROM CURB
C. FACING UP-OR DOWN-HILL WITH NO CURB TURN WHEELS TOWARD SHOULDER

Figure 5-3.—Positioning the wheels of a parked vehicle.

NOTE: A majority of the backing mishaps that have occurred in the NCF could have been avoided had the operators used a backup guide.

4. Ensure the reverse signal alarm works when you make the prestart operational inspection. If your vehicle is equipped with a reverse signal alarm, it must work during the entire backward movement of the vehicle.

EXPRESSWAYS

Expressways are designed for high-speed driving, and to avoid mishaps on them, drivers must be more skillful and alert. All expressway entrances have three basic parts: an entrance ramp, an acceleration lane, and a merging area. (See fig. 5-4.)

On the entrance ramp, begin to speed up and check for an opening in traffic. Be sure to signal before entering. As the ramp straightens into the acceleration lane, continue to speed up. Try to adjust your speed so you can move into traffic. Merge into traffic when you can do so safely. You must yield the right-of-way to traffic on the expressway. You cannot always count on other drivers moving over to give you room to enter, but do not stop on an acceleration lane unless traffic is heavy and there is no space for you to enter safely.

When traveling on an expressway, you should never exceed the posted speed limit and should maintain the distance between vehicles needed for safe stopping. Avoid highway hypnosis by taking rest stops and opening vents or windows. Should you have and emergency situation develop, you should get the vehicle off the expressway as fast as safely possible. After coming to a stop, you should look behind you for oncoming or passing traffic before opening any door on the vehicle. When safe to do so, exit the vehicle and place flasher lights or flares behind the vehicle to warn other motorists.

When you are leaving expressways, get in the proper lane well before the turnoff, and use turn signals to warn other drivers. Slow down in the deceleration lane only. Check the posted speed for the exit ramp. (See fig. 5-5.) Be prepared to obey posted signs like stop, yield, or merge. Should you miss your exit, do not stop or backup to the ramp. You must go to the next exit to turn around.

PERIODIC STOPS

Driving for long distances or operating equipment for long periods of time can become hypnotic. You need to stop at least every couple of hours and walk around your vehicle to wake up and loosen up. This improves your awareness and allows you to operate the equipment more safely.

While you are stopped and walking around, look over your vehicle; give it a quick safety inspection.

1. Look at your tires. Check the lug nuts and ensure they are tight.
2. Listen for any air leaks. Look for leaks that may occur during operation from the engine, transmission, or differential.
3. Look at the general condition of your vehicle.
4. Check the load to see if it has shifted.

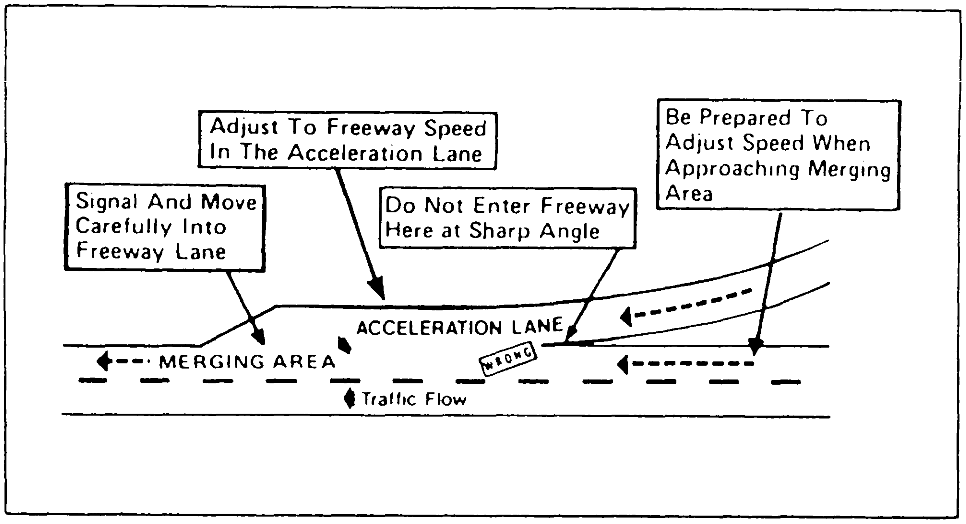

Adjust To Freeway Speed In The Acceleration Lane
Be Prepared To Adjust Speed When Approaching Merging Area
Signal And Move Carefully Into Freeway Lane
Do Not Enter Freeway Here at Sharp Angle
ACCELERATION LANE
MERGING AREA
WRONG
Traffic Flow

Figure 5-4.—How to enter an expressway safely.

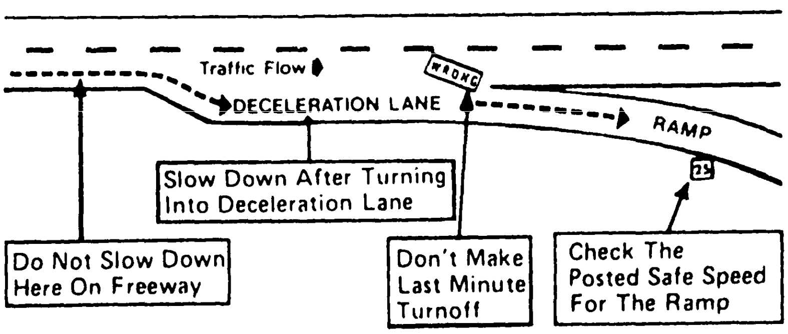

Traffic Flow
WRONG
DECELERATION LANE
RAMP
25
Slow Down After Turning Into Deceleration Lane
Do Not Slow Down Here On Freeway
Don't Make Last Minute Turnoff
Check The Posted Safe Speed For The Ramp

Figure 5-5.—How to exit an expressway safely.

5. Ensure your vehicle is safe to operate the remainder of your shift.

Check your physical condition. You, as the operator, have to be honest with yourself. Are you physically able to drive or operate the equipment for the remainder of the shift? Any mishap you have on the public road or on the jobsite that affects the community reflects negatively not only yourself, but the Navy as well. Stay alert when driving or operating. Be a good representative.

DRIVING UNDER HAZARDOUS CONDITIONS

Driving under hazardous conditions requires special skills and your undivided attention. The following paragraphs contain some guidelines intended to make you a good operator under adverse driving conditions.

SNOW AND ICE

Snow and ice severely limit the traction of a vehicle. When you are moving over fresh snow, maintain a slow, steady speed. Rapid acceleration is likely to cause skidding or cause the wheels to dig in. Should your vehicle become stuck in a hole in the snow, rocking it back and forth by shifting from forward to reverse may enable you to start again. Brakes, when used, should be applied lightly and released quickly if skidding begins.

Hard-packed snow or ice is more dangerous to drive on than fresh snow. To increase traction, put chains on all driving wheels. Snow tires are not much help on ice, as they add little or no traction and give you a false feeling of security. Deflating the tires a bit assists in preventing skidding.

Snow and ice affect visibility, stopping distance, maneuverability, and vehicle control. For driving under such conditions, you should take the following precautions:

1. Adjust the speed of the vehicle to existing conditions.
2. Under normal conditions, allow at least one car length between vehicles for each 10 miles per hour (mph) of speed you are traveling at. Increase the normal safe distance between vehicles to allow for hazardous conditions.
3. Use tire chains or snow tires on ice or snow; however, remember that they are only an aid to increase traction and do not eliminate the necessity for added caution.
4. Slow down when approaching bridges, overpasses, and shady areas in the road; surfaces in such areas often freeze before regular roadway surfaces do and remain frozen longer.
5. Keep the outside of the windshield and windows clear of snow, ice, and frost at all times, and use the vehicle defroster to improve visibility. Turn on headlight and use extreme caution when driving in fog.
6. Apply brakes with a light pumping action to prevent skidding and use engine compression to help control the vehicle.

7. Signal well in advance to warn others of an intended stop or turn.

WET ROADS

When driving through water, reduce speed to prevent the brake drums, engine, and ignition from getting wet. Apply foot pressure on the brake pedal just before entering and during passage through water deep enough to enter the brakes. Test the brakes for effectiveness immediately after leaving the water. If water has entered the brake drums and wet the linings, drive very slowly while gently applying sufficient pressure on the brake pedal to cause a slight drag, thereby squeezing the brake linings against the drums and forcing the water out of the linings.

Most roads are more slippery just after it begins to rain. This is because oil, that has dropped from vehicles traveling the road, forms a film on the road. Under these conditions, an operator should proceed at a slow speed because at least twice the normal stopping distance is needed to stop a vehicle.

When roads are wet, your tires may ride on a thin film of water, like skis. This condition is called **hydroplaning** and you can easily lose control and skid when your tires are not touching the road. Keep your tires on the road by slowing down when it rains and by having the correct air pressure and good tread on your tires.

NIGHT DRIVING

Some operators try to drive just as fast at night as they do in the daytime. Speed should always be reduced for nighttime driving.

NIGHT DRIVING IS TWO TO THREE TIMES MORE DANGEROUS THAN DAY DRIVING. Fatigue and sharply reduced vision are the primary causes for increased danger. The steady hum of the motor and the darkness on the road ahead tend to lull us to sleep at the wheel. Wide-awake driving is necessary at all times and especially at night, since we cannot see as well at night as we can in daylight. Driving safely after dark requires particular skills and extra care.

The following are requirements and practices applicable to night driving which should be carefully observed:

- Lower the beams of your headlights when within 500 feet of an approaching vehicle.
- Lower the beams of your headlights when within 200 feet of a vehicle in front of you.
- Lower the beams of your headlights when you are driving on well-illuminated streets.
- Use your low-beam headlights when driving in fog, and reduce your speed. Driving with your high beams in fog is like shining your high-beam headlights on a mirror—light is reflected back into your eyes and blinds you.
- Use your high-beam headlights when it is safe and legal. Using low-beam highlight all the time cuts down on your ability to see ahead. Use your high-beams when you are **NOT** within 500 feet of an approaching vehicle.
- Avoid looking directly into the lights of oncoming vehicles. Instead, watch the right-hand edge of the road.
- Keep your headlights properly adjusted so the lower beams are not aimed upward into the approaching driver's eyes.
- Keep your windshield clean.
- Slow down when facing the glare from approaching headlights.
- Be sure you can stop, when necessary, within the vision distance of the headlights of your vehicle, and watch constantly for pedestrians along the roadside.
- Use your headlights from one-half hour before sunset to one-half hour after sunrise and at any time visibility is reduced.

FOG OR SMOKE

Driving in fog or smoke greatly reduces visibility. Use the techniques described earlier for driving on wet roads. Again, slow down, turn on your low-beam headlights, and be ready for a fast stop.

DRIVING UNDER SPECIAL CONDITIONS

You may have to operate a vehicle in unique conditions. The way you perform under these conditions are discussed in the following paragraphs.

SAND

The major problem sand presents is to gain traction without digging in. Sand can be stabilized with a large volume of water but loosens as soon as it dries out. Often, tires spin and dig into the sand rapidly which causes a jerking motion in the drive line.

NOTE: This jerking motion can cause severe damage to axles, differentials, and propeller shafts. All-wheel drive vehicles have less difficulty, but they consume considerable power.

Should you have to operate in sand, there are some actions you can take to help you out when a winch is not available. Partially deflate your tires; this gives your tires a wider footprint for traction. You can use mats of brush, wire, grass, lumber or anything that can “bridge over” and allow you to spread the load of your vehicle over a larger area.

CROSS-COUNTRY

Driving cross-country can produce many problems. Should you have to drive cross-country, it is best to have someone walk in front of your vehicle to look for holes, stumps, and ditches that may damage your vehicle. Proceed slowly and use the lowest gear possible. Avoid wet, marshy areas if possible because a marsh will crust over and break through if you drive over it. When it breaks through, there is little you can do but call for assistance to be towed.

Watch out for stumps, rocks, or anything on which you may get high center. Sometimes it is better to keep your tires on large rocks and go over them, rather than straddle them. Stumps may be cut off for your vehicle to clear.

DRIVING HOURS

Driving hours are regulated by the U.S. Department of Transportation, Code of Federal Regulations, Title 49. These regulations are reflected in the *Federal Motor Carrier Safety Regulations Pocketbook, ORS-7A.* You are restricted to drive no longer than 10 hours in a 15-hour period after 8 hours off duty. You, the operator, are responsible for the safe operation of your vehicle.

As a safety measure, an operator should take breaks or rest stops when becoming fatigued or sleepy. After parking the vehicle, get out and walk around to stretch your muscles. Rest stops are especially important on a long trip requiring many hours of driving.

WARNING

Extended periods of driving often results in **driver fatigue.** Physical and mental fatigue brought on by extended periods of time behind the wheel is a frequent problem encountered by operators. If operators are exhausted, they may doze at the wheel and lose control of the vehicle, resulting in a serious or fatal mishap.

MOUNTAIN DRIVING

The force of gravity plays a major role in mountain driving. If you have a heavy load or a fully loaded bus, you must select lower gears to climb the hills. When going down steep hills, the pull of gravity speeds you up. You must go slow so your brakes can hold you back without overheating. If the brakes become too hot, they may start to “fade.” This means that you have to apply them harder and harder to get the same stopping power. When the brakes continue to be used hard, they continue to fade until you cannot slow down or stop at all.

Use of Gears

No matter what size of vehicle you are descending long, steep grades in, going too fast can cause your brakes to fail. Lower gears allow engine compression and friction to help slow the vehicle. This is true whether you have an automatic or a manual transmission.

When you are operating a large vehicle with a manual transmission or a fully loaded bus, do not wait until you have started down a hill to shift down. You could get hung up in neutral and find yourself coasting, which is not only illegal but is also dangerous. Remember: Choose the right gear before starting down a hill.

For older trucks, the rule of thumb for choosing gears is to use the same gear going down a hill that you would use to climb the hill. New trucks have low friction parts and streamlined shapes for fuel economy and often have more powerful engines. This allows them to go up hills in higher gears. They also have less friction and air drag to hold them back when going down a hill. For this reason, operators of newer trucks often have to use **lower gears going down** a hill than needed to go up the hill.

Proper Braking

When going downhill, brakes tend to heat up. When engaged, the brake pads and shoes rub against the brake disc and drums, creating heat. Brakes are designed to withstand intense heat; however, brakes can fail from excessive heat if you try to slow down from a high speed too many times too quickly. Brakes fade (have less stopping power) when they get hot and may not slow the vehicle.

The correct way to use your brakes for long downhill grades is to go slow enough that fairly light use of the brakes prevents your speed from increasing. When you go slow, the brakes can cool down.

Some operators think that backing off on the brakes from time to time (fanning) allows them to cool enough to prevent overheating. Tests have proven this is not true. Brake drums cool slowly, so the amount of cooling between applications is not enough to prevent overheating. This type of braking requires heavier brake pressure than steady application does. The heavier pressure used on the brakes builds up more heat than the light continuous pressure does; therefore, select the right gear, go slow, and maintain a lighter, steadier use of the brakes.

Escape Ramps

Escape ramps are constructed on most steep mountain grades. They are used to stop runaway vehicles safely without injury to drivers or passengers. Escape ramps use along bed of loose soft material, such as pea gravel or sand, to slow a runaway vehicle. Sometimes, they are used in combination with an upgrade.

VEHICLE RECOVERY

Recovery is a major operation. During any recovery operation, always use a proven procedure. A haphazard approach to a recovery problem or the use of a trial-and-error method can be a costly mistake. Such a mistake can “deadline” the disabled vehicle longer than necessary, cost valuable time, damage equipment, and injure personnel. Self-recovery of vehicles, recovery with wreckers, and recovery with like-vehicles are discussed in this section.

WRECKERS

Recovery, using wrecker trucks, should be performed by trained recovery personnel of Alfa company or the transportation division. An understanding of the ability of the vehicle to winch, lift, and tow is very important. For in-depth information, refer to the operator’s manual that relates to the operation of specific equipment and their specific abilities.

Mired Truck

The recovery of a mired truck using a wrecker truck is not always an easy task because it involves the resistance of the load, the approach to the load, and the distance between the wrecker and the mired vehicle. Use a direct pull if the resistance created by the mired vehicle is less than the winch capacity of the wrecker.

CAUTION

> Do not hook the winch cable around the bumper on a vehicle. Wrapping the tow cable around the bumper of a mired vehicle will result in a bent bumper.

An example of a simple winching operation is shown in figure 5-6. Some winching operations are more difficult. The mired truck may have a resistance greater than the winch capacity of the wrecker. Also, the wrecker may not be able to align itself with the truck due to terrain. If so, use a 2:1 mechanical advantage and a change of direction pull, as shown in figure 5-7.

Nosed Truck

The recovery of a nosed truck using a wrecker truck may require only a towing operation. Some situations may require all three of the capabilities (winching,

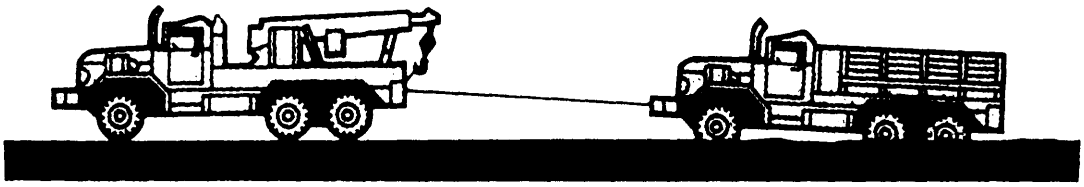


Figure 5-6.-Simple winch operation (direct pull).

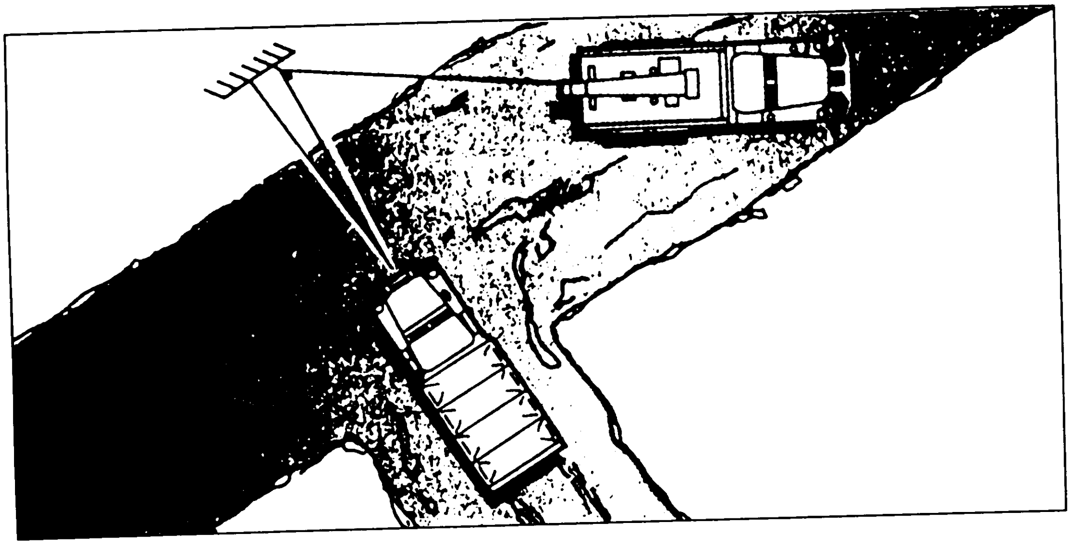


Figure 5-7.—Mechanical advantage and change of direction (winching).

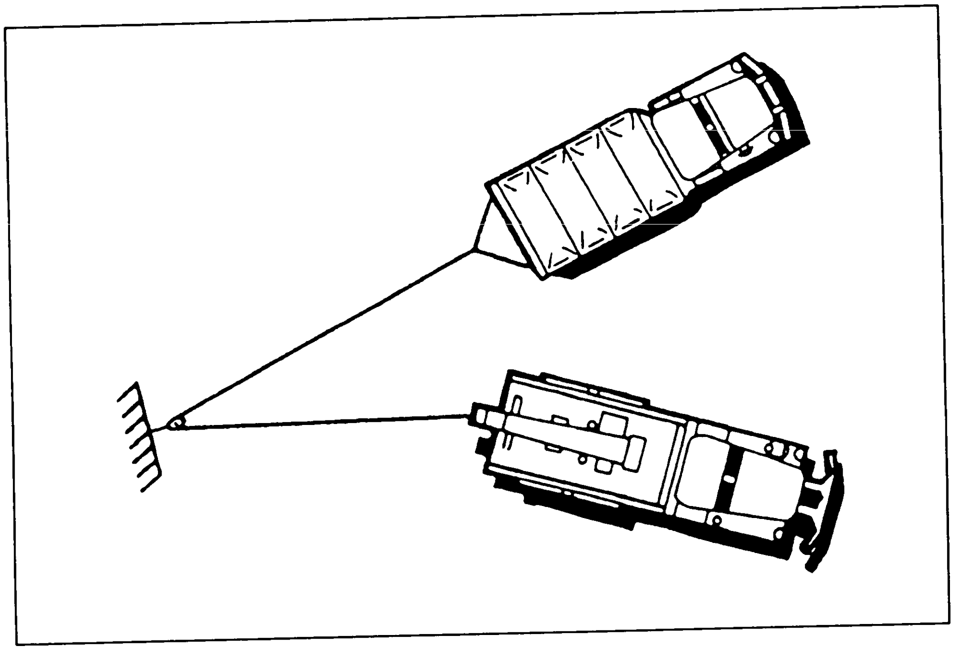


Figure 5-8.—Winching by change of direction

lifting, and towing) of the trucks to complete the recovery.

Figure 5-8 shows a mechanically disabled 2 1/2-ton truck nosed off a narrow road in such a way that the wrecker cannot be positioned directly behind the vehicle. You may notice that the winch cable is not running in a direct straight line with the winch. On a normal winch, this angle causes the wire rope to wind off the side (flange) of the winch drum; however, the wrecker winch has a level winding device that offsets the difference. Other vehicles with winches do not have this device.

Overturned Truck

To upright an overturned truck with a wrecker truck, you should use a sling method of attachent, because a pulling force applied to only one point of the frame can result in a bent frame. A sling lifting attachent is made up of either two utility chains or two 1-inch fiber ropes. The sling ends are attached to the front and rear lifting devices on the high side of the overturned truck. Then the winch cable is attached to the center of the sling. A holding force is required to prevent the overturned vehicle from crashing onto its wheels. The holding force

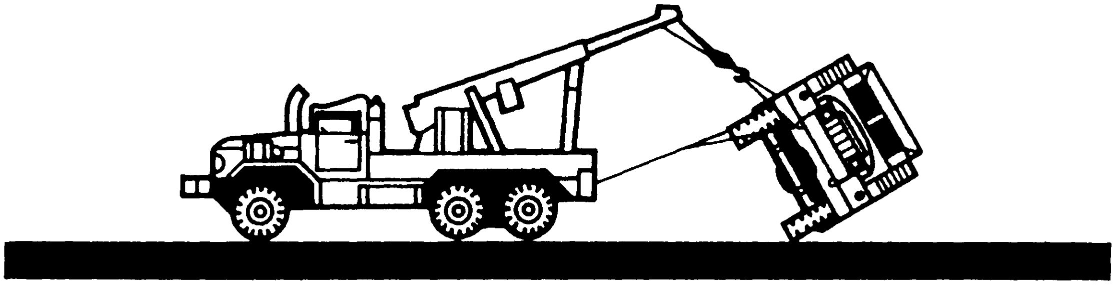


Figure 5-9.—Righting an overturned truck.

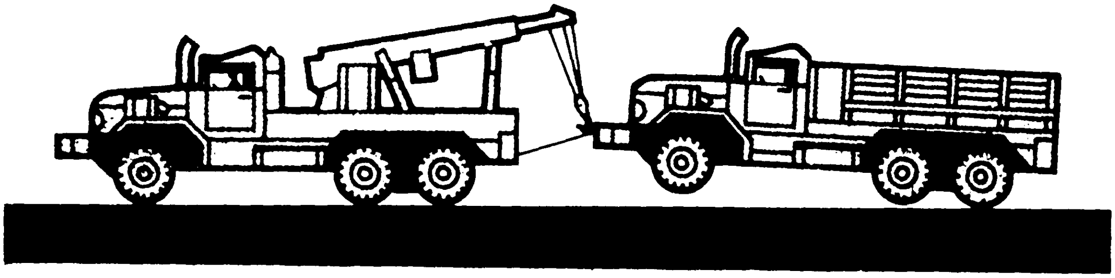


Figure 5-10.—Highway tow.

could be another vehicle, the wrecker boom, or a rope block and tackle with manpower.

The attachment for the holding force is a holding sling attached to the same points on the overturned truck as the pulling sling. The holding sling is then attached to the holding force with wire rope, rope, or chain, making sure the holding force is attached to the center of the sling. If a holding vehicle is not available, use the wrecker boom to hold the load, as shown in figure 5-9.

Apply power gradually to the winch until the overturned truck is past the vertical position. Then lower the truck on its wheels with the hoist winch, rather than booming out with the crane.

NOTE: Maximum use of the boom jacks and outriggers should be employed when this method is used.

Towing

A wrecker truck is capable of towing vehicles in several ways. The proper procedures and safety guidelines for towing are important factors in preventing damage to vehicles and injury to personnel. The basic procedures and guidelines for highway towing and cross-country towing are as follows:

HIGHWAY TOW.— Attach the tow bar to the lifting shackle eyes of the disabled vehicle and the wrecker truck tow pintle. All wheels of the towed vehicle should be on the ground. With the tow bar, a driver is not required in the towed vehicle. (See fig. 5-10.)

CROSS-COUNTRY TOW.— Over rough terrain, across-country tow controls the towed vehicle well. The procedure for rigging for the cross-country tow is as follows: (1) attach a chain lifting sling or the hoisting bar between the front lifting shackles of the truck; (2) attach a tow chain from the wrecker tow pintle to the lifting shackles of the disabled truck; (3) place the hoist hook block in the lifting sling approximately 12 inches off the ground; (4) extend the boom to remove the slack from the tow chain, and keep the towed vehicle from ramming into the rear of the wrecker truck; and (5) support the boom with the shipper braces to prevent impact loads on the crane mechanisms. (See fig. 5-11.)

If the front end of the vehicle is damaged, use cross-country towing even though the disabled vehicle is being towed on the highway. Use the tow bar instead of a tow chain.

SELF- AND LIKE-VEHICLE RECOVERY

A winch-equipped mired vehicle can perform self-recovery. Attach the snatch block to a suitable anchor and the free end of the cable to a chain sling connected to both of the front lifting shackles of the mired vehicle. A fixed block provides a mechanical advantage on a self-winching operation, even though the sheave of the block is performing as a first-class lever. (See fig. 5-12.)

Use a similar wheeled vehicle as the source of effort to perform recovery by towing and winching. For vehicles not equipped with lifting shackles, attach a tow chain to the main structural members. Before towing or recovering a disabled vehicle, check the vehicle operator's manual to ensure that all physical and safety features are considered. This must be done to prevent additional damage to the disabled vehicle.

To recover a mired truck by towing with a similar vehicle, use a tow chain or a wire rope sling between the towing vehicle and the mired vehicle. Attach it to one lifting shackle of the mired vehicle and through the tow pintle on the towing vehicle.

Apply power slowly to prevent shock to the towing device and lifting shackles. If one towing vehicle cannot attain sufficient towing effort to overcome the resistance, use another towing vehicle in tandem with the first, as shown in figure 5-13.

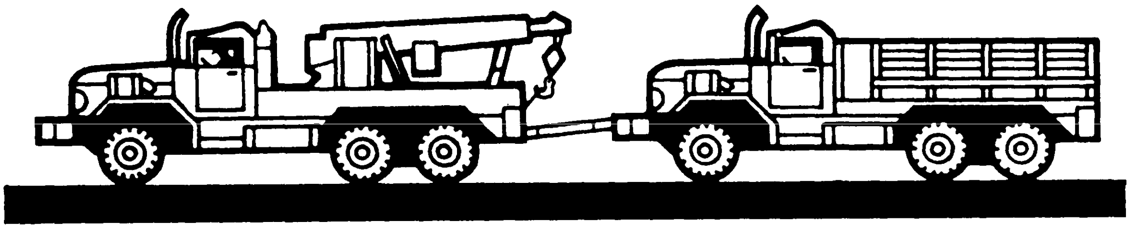


Figure 5-11.-Cross-country tow.

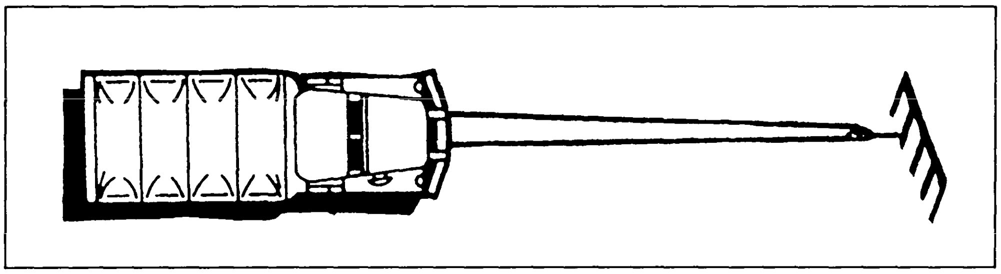


Figure 5-12.-Self-winching.

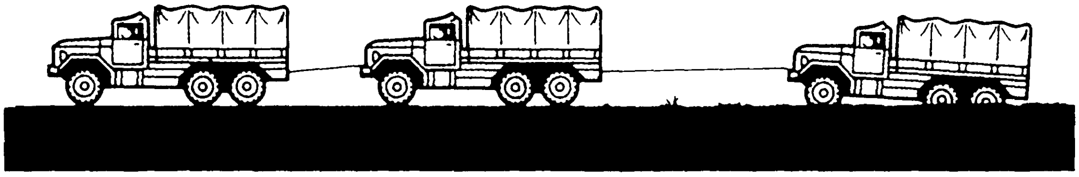


Figure 5-13.—Like-vehicle recovery.

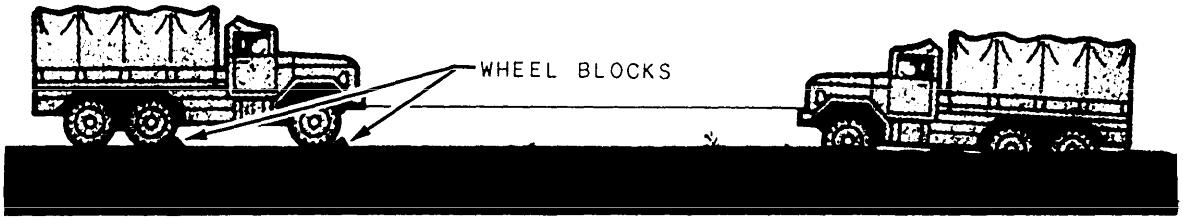


Figure 5-14.—Winching with a like-vehicle.

To winch a mired truck, use a truck with a winch of equal or greater capacity to perform the recovery. Often, the winching or recovery vehicle must be anchored by more than its own weight. Place wheel blocks, chocks, or natural material in front of the front wheels of the recovery vehicle. (See fig. 5-14.) For more information on vehicle recovery, refer to *Vehicle Recovery Operations, FM 22-20.*

INTERNATIONAL SIGNALS AND ROAD SIGNS

The international system used for traffic control devices emphasizes pictures and symbols, rather than written messages. Symbols have several advantages over word messages, such as the following: (1) they provide almost instant communication with the driver, because they can be understood at a glance without having to be read; and (2) they overcome language barriers which is important because of the growth of international travel. Familiarity with the symbolic signs can help Americans traveling abroad as well as foreigners visiting the United States. As the new signs are introduced, companion word messages will also be used until the public becomes accustomed to the new system. Figure 5-15 shows several traffic signs and markings that are used on U.S. roadways.

Additional international signals and road signs are illustrated in appendix II. The color and shape of these signs are important.

COLORS

Red indicates a stop or a prohibition. **Green** shows movement permitted or gives directional guidance. **Blue** is for signs leading to motorist services. **Yellow** indicates a general warning. **Black on white** indicates regulatory signs, such as those for speed limits. **Orange** conveys construction and maintenance warnings. **Brown** is for public recreation and scenic guidance.

SHAPES

Diamond-shaped signs signify a warning. **Rectangular** signs with the longer dimension vertical contain a traffic regulation. **Rectangular** signs with the longer dimension horizontal contain guidance information. An octagon means stop; an **inverted triangle** means yield. A **pennant** means no passing; a **pentagon** shows the presence of a school. A **circle** warns of a railroad crossing.

PAVEMENT MARKINGS

Road markings on highways are yellow and white; however, each has a different meaning. White lines separate lanes of traffic going in the same direction. Yellow markings separate lanes of traffic traveling in different directions.

Solid yellow lines indicate there should be no passing from either direction. **Broken yellow lines** indicate that you can pass with caution. Remember: You are traveling on a highway with traffic going in both directions.

Solid white lines indicate there should be no lane changing. They are used at stoplights, turning lanes, and intersections on highways. **Broken white lines** indicate that cautious lane changes may be made.

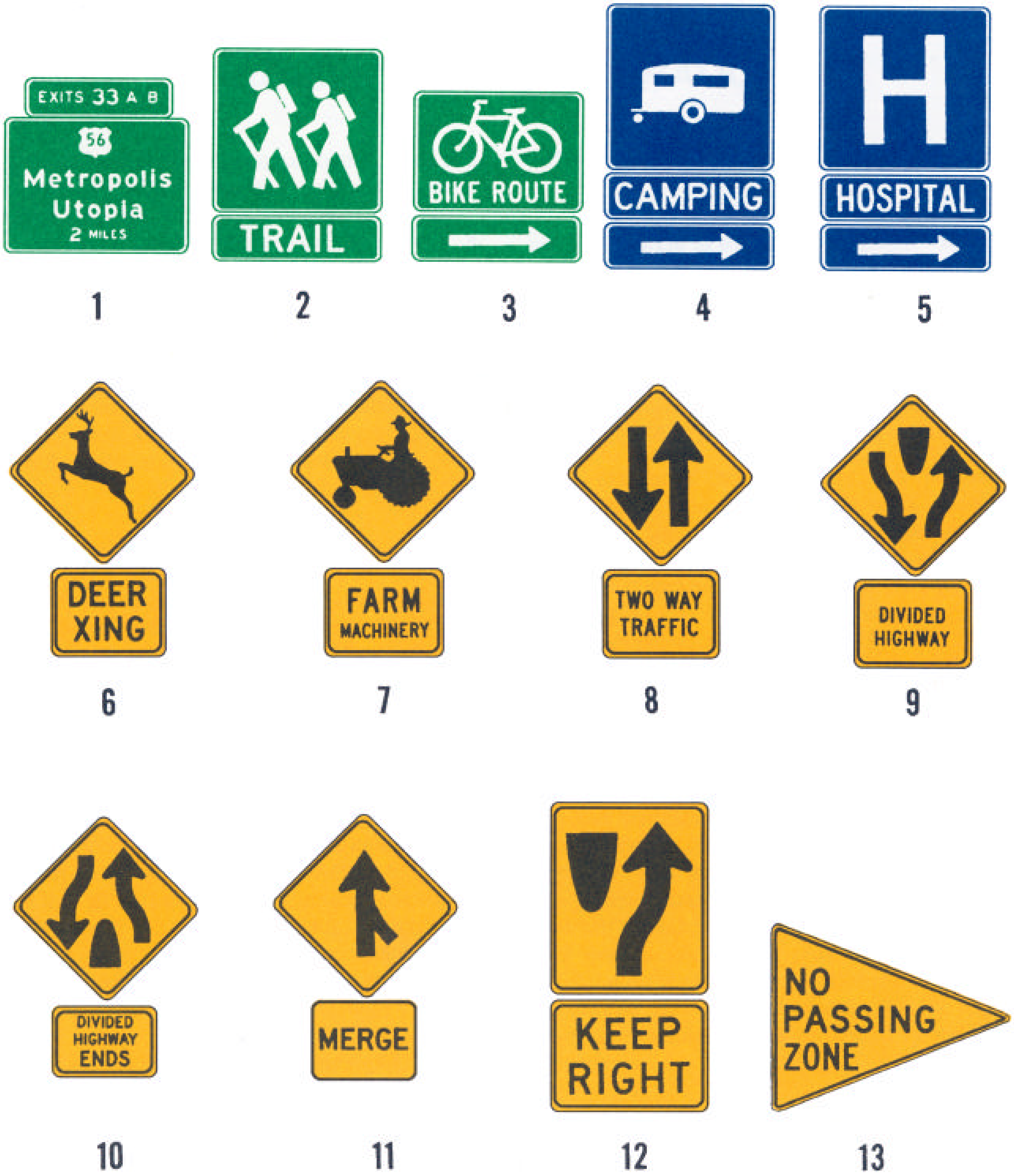

EXITS 33 A B
56
Metropolis
Utopia
2 MILES
1
TRAIL
2
BIKE ROUTE
3
CAMPING
4
H
HOSPITAL
5
DEER XING
6
FARM MACHINERY
7
TWO WAY TRAFFIC
8
DIVIDED HIGHWAY
9
DIVIDED HIGHWAY ENDS
10
MERGE
11
KEEP RIGHT
12
NO PASSING ZONE
13

Figure 5-15.—Traffic signs and markings.

CHAPTER 6

TRANSPORTATION OPERATIONS

Transportation operations consist of the control and accountability of all Civil Engineer Support Equipment (CESE); the hauling of personnel, equipment, materials, and construction supplies; the storage and delivery of petroleum products; the storage and accountability of collateral equipment and attachments; the support of construction projects; and the support of the maintenance program by cycling, washing, greasing, and processing CESE through the mechanic shops. This chapter presents the basic information required for you to perform your duties effectively when assigned to support the operations of a transportation pool.

ADMINISTRATION

The Navy has invested millions of dollars in equipment, equipment repair parts, lubricants, and training that allows the Seabees to perform assigned tasking. Having the basic knowledge of the procedures, reports, and forms used in the management of the transportation pool or department is part of your responsibility as an Equipment Operator.

LICENSE

Navy policy, according to the *Management of Transportation Equipment,* NAVFAC P-300, is to ensure that all military personnel, civilian employees, and contractor personnel operating vehicles and equipment on a naval installation are qualified and properly licensed. Navy policy accepts, without further testing and examination, a valid operator's license issued by a state or jurisdiction as proof the applicant has achieved the proficiency level required to operate government vehicles up to 10,000 pounds gross vehicle weight (GVW).

According to the *Equipment Management Manual*, NAVFAC P-404, all personnel in the NCF and special operating units (SOUs) who operate government-owned or rented equipment must be qualified and have a valid U.S. Government Operator's License in their possession. This license must cover the size and type of vehicle to be operated. A Government Operator's License is not an authorization for an operator to use a piece of equipment. The proper authorization is a valid trip ticket.

APPLICATION FORMS

To obtain an operator's license, you must submit an application form to the license examiner. The proper form to, use in applying for an automotive or material-handling equipment (MHE) license is an Application for Vehicle Operator's Identification Card, NAVFAC 11240/10 (figs. 6-1A and 6-1B). The form used to apply for a license for other type of equipment is the Application for Construction Equipment Operator License, NAVFAC 11260/1 (figs. 6-2A and 6-2B).

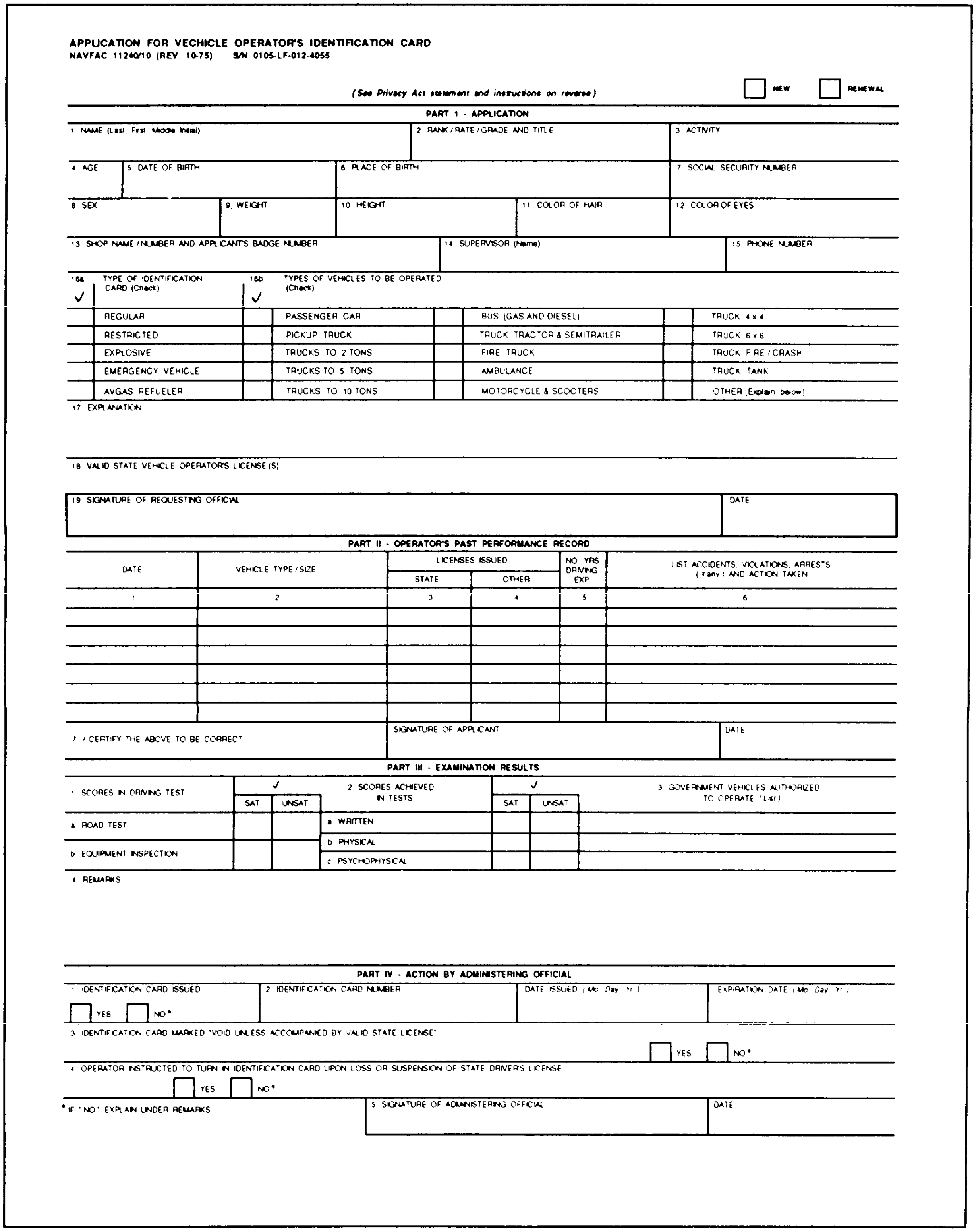
These forms provide information pertinent to applying for and issuing or denying licenses to applicants. The type of license being requested must be shown in part 1 of the application forms. All applicant forms are completed by the applicant and are signed by the company commander or the company chief. The license examiner maintains the NAVFAC 11240/10, NAVFAC 11260/1, and the Standard Form 47 in a file for each person who possesses a license.

STANDARD FORM 47

The Standard Form 47 (fig. 6-3) is the Physical Fitness Inquiry for Motor Vehicle Operators. As an operator, you must have no physical defects or emotional instability that make you a hazard to yourself and others. The license examiner will review and evaluate this form, plus any other available information regarding your physical condition and determine if a physical examination is required. Physical examinations are performed by the Medical Department.

LICENSE TEST

Part of the process for receiving a license is to take a written test administered by the license examiner. These tests are based on traffic laws and regulations, accident reporting procedures, operator's maintenance responsibilities, safe driving practices, and the characteristics and limitations of the types of equipment for which the test is being given. If you need information particular to a piece of equipment, you can obtain the operator's manual located in the technical



APPLICATION FOR VECHICLE OPERATOR'S IDENTIFICATION CARD
NAVFAC 11240/10 (REV. 10-75) S/N 0105-LF-012-4055

(See Privacy Act statement and instructions on reverse)

☐ NEW ☐ RENEWAL

PART 1 - APPLICATION

1 NAME (Last, First, Middle Initial)	2 RANK/RATE/GRADE AND TITLE	3 ACTIVITY	
4 AGE	5 DATE OF BIRTH	6 PLACE OF BIRTH	7 SOCIAL SECURITY NUMBER

8 SEX	9. WEIGHT	10 HEIGHT	11 COLOR OF HAIR	12 COLOR OF EYES

13 SHOP NAME/NUMBER AND APPLICANT'S BADGE NUMBER	14 SUPERVISOR (Name)	15 PHONE NUMBER

16a ✓	TYPE OF IDENTIFICATION CARD (Check)	16b ✓	TYPES OF VEHICLES TO BE OPERATED (Check)				
☐	REGULAR	☐	PASSENGER CAR	☐	BUS (GAS AND DIESEL)	☐	TRUCK 4 x 4
☐	RESTRICTED	☐	PICKUP TRUCK	☐	TRUCK TRACTOR & SEMITRAILER	☐	TRUCK 6 x 6
☐	EXPLOSIVE	☐	TRUCKS TO 2 TONS	☐	FIRE TRUCK	☐	TRUCK FIRE/CRASH
☐	EMERGENCY VEHICLE	☐	TRUCKS TO 5 TONS	☐	AMBULANCE	☐	TRUCK TANK
☐	AVGAS REFUELER	☐	TRUCKS TO 10 TONS	☐	MOTORCYCLE & SCOOTERS	☐	OTHER (Explain below)

17 EXPLANATION

18 VALID STATE VEHICLE OPERATOR'S LICENSE (S)

19 SIGNATURE OF REQUESTING OFFICIAL	DATE

PART II - OPERATOR'S PAST PERFORMANCE RECORD

DATE	VEHICLE TYPE/SIZE	LICENSES ISSUED		NO YRS DRIVING EXP	LIST ACCIDENTS, VIOLATIONS, ARRESTS (If any) AND ACTION TAKEN
		STATE	OTHER		
1	2	3	4	5	6

7 I CERTIFY THE ABOVE TO BE CORRECT	SIGNATURE OF APPLICANT	DATE

PART III - EXAMINATION RESULTS

1 SCORES IN DRIVING TEST	✓		2 SCORES ACHIEVED IN TESTS	✓		3 GOVERNMENT VEHICLES AUTHORIZED TO OPERATE (List)
	SAT	UNSAT		SAT	UNSAT	
a ROAD TEST			a WRITTEN			
			b PHYSICAL			
b EQUIPMENT INSPECTION			c PSYCHOPHYSICAL			

4 REMARKS

PART IV - ACTION BY ADMINISTERING OFFICIAL

1 IDENTIFICATION CARD ISSUED ☐ YES ☐ NO*	2 IDENTIFICATION CARD NUMBER	DATE ISSUED (Mo Day Yr)	EXPIRATION DATE (Mo Day Yr)

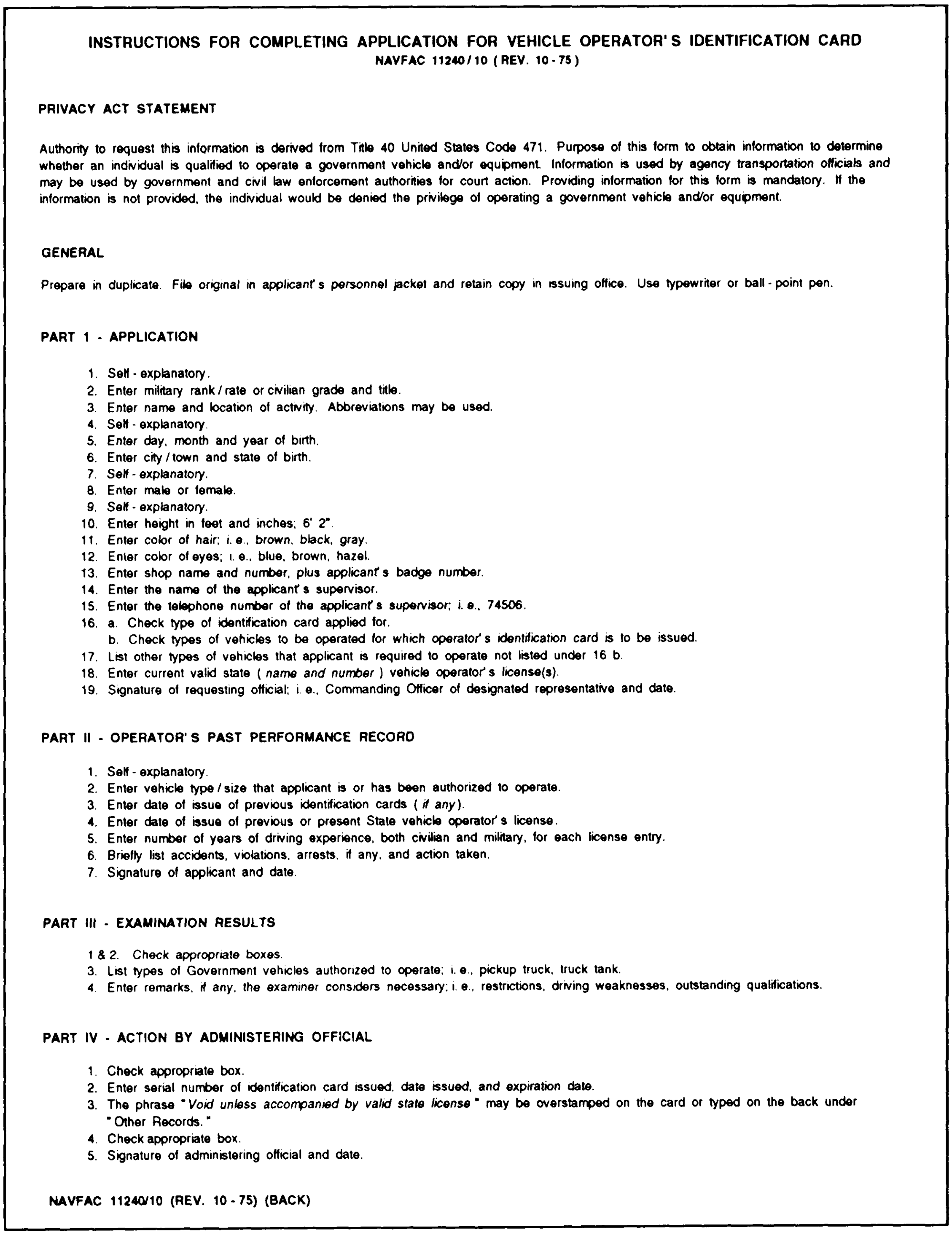
3 IDENTIFICATION CARD MARKED "VOID UNLESS ACCOMPANIED BY VALID STATE LICENSE" ☐ YES ☐ NO*

4 OPERATOR INSTRUCTED TO TURN IN IDENTIFICATION CARD UPON LOSS OR SUSPENSION OF STATE DRIVER'S LICENSE ☐ YES ☐ NO*

*IF "NO" EXPLAIN UNDER REMARKS

5 SIGNATURE OF ADMINISTERING OFFICIAL	DATE

Figure 6-1A.-Application for Vehicle Operator's Identification Card, NAVFAC 11240/10 (front).



INSTRUCTIONS FOR COMPLETING APPLICATION FOR VEHICLE OPERATOR'S IDENTIFICATION CARD
NAVFAC 11240/10 (REV. 10-75)

PRIVACY ACT STATEMENT

Authority to request this information is derived from Title 40 United States Code 471. Purpose of this form to obtain information to determine whether an individual is qualified to operate a government vehicle and/or equipment. Information is used by agency transportation officials and may be used by government and civil law enforcement authorities for court action. Providing information for this form is mandatory. If the information is not provided, the individual would be denied the privilege of operating a government vehicle and/or equipment.

GENERAL

Prepare in duplicate. File original in applicant's personnel jacket and retain copy in issuing office. Use typewriter or ball-point pen.

PART 1 - APPLICATION

1. Self-explanatory.
2. Enter military rank/rate or civilian grade and title.
3. Enter name and location of activity. Abbreviations may be used.
4. Self-explanatory.
5. Enter day, month and year of birth.
6. Enter city/town and state of birth.
7. Self-explanatory.
8. Enter male or female.
9. Self-explanatory.
10. Enter height in feet and inches; 6' 2".
11. Enter color of hair; i. e., brown, black, gray.
12. Enter color of eyes; i. e., blue, brown, hazel.
13. Enter shop name and number, plus applicant's badge number.
14. Enter the name of the applicant's supervisor.
15. Enter the telephone number of the applicant's supervisor; i. e., 74506.
16. a. Check type of identification card applied for.
    b. Check types of vehicles to be operated for which operator's identification card is to be issued.
17. List other types of vehicles that applicant is required to operate not listed under 16 b.
18. Enter current valid state (*name and number*) vehicle operator's license(s).
19. Signature of requesting official; i. e., Commanding Officer of designated representative and date.

PART II - OPERATOR'S PAST PERFORMANCE RECORD

1. Self-explanatory.
2. Enter vehicle type/size that applicant is or has been authorized to operate.
3. Enter date of issue of previous identification cards (*if any*).
4. Enter date of issue of previous or present State vehicle operator's license.
5. Enter number of years of driving experience, both civilian and military, for each license entry.
6. Briefly list accidents, violations, arrests, if any, and action taken.
7. Signature of applicant and date.

PART III - EXAMINATION RESULTS

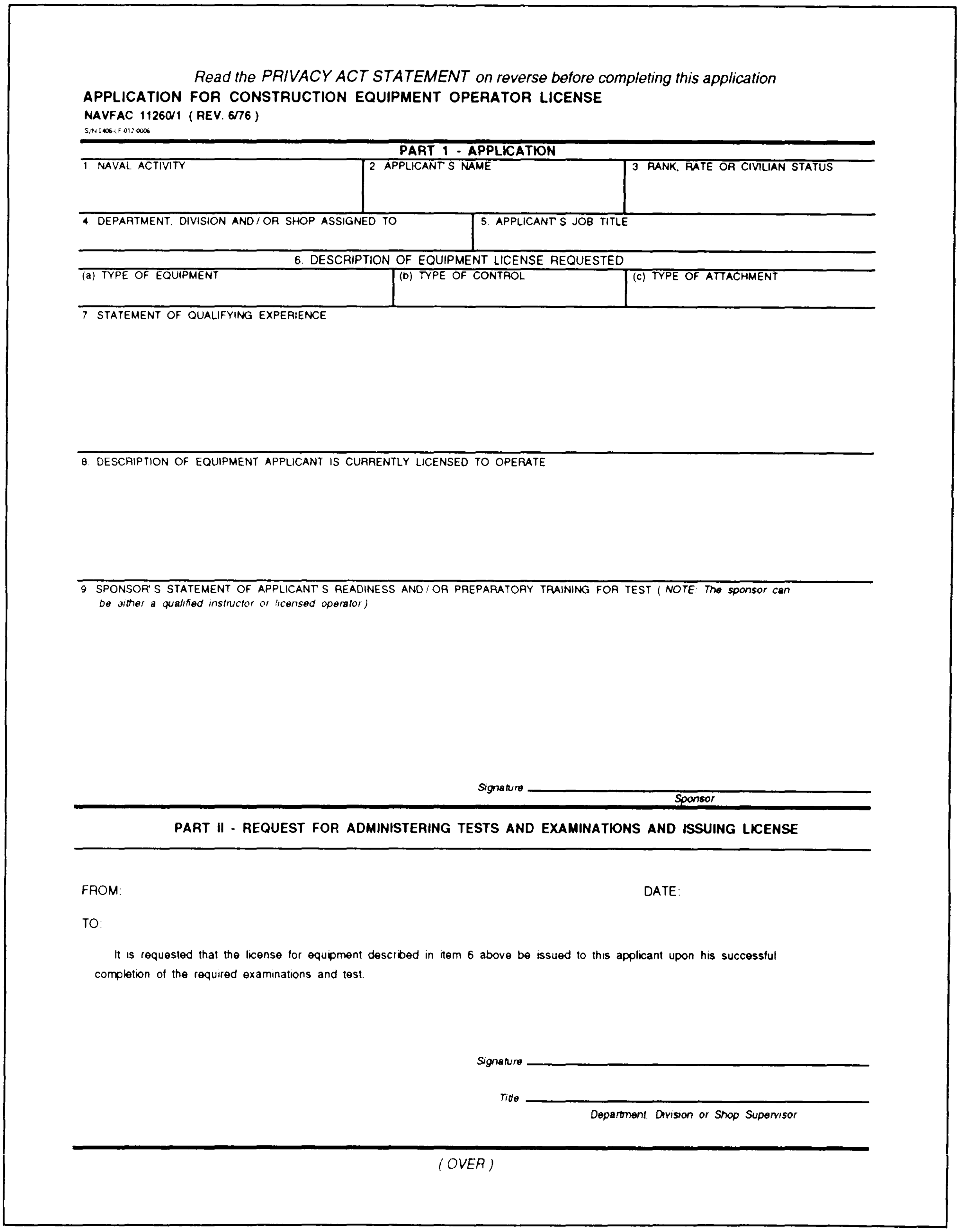
1 & 2. Check appropriate boxes.
3. List types of Government vehicles authorized to operate; i. e., pickup truck, truck tank.
4. Enter remarks, if any, the examiner considers necessary; i. e., restrictions, driving weaknesses, outstanding qualifications.

PART IV - ACTION BY ADMINISTERING OFFICIAL

1. Check appropriate box.
2. Enter serial number of identification card issued, date issued, and expiration date.
3. The phrase "*Void unless accompanied by valid state license*" may be overstamped on the card or typed on the back under "Other Records."
4. Check appropriate box.
5. Signature of administering official and date.

NAVFAC 11240/10 (REV. 10-75) (BACK)

Figure 6-1B.-Application for Vehicle Operator's Identification Card, NAVFAC 11240/10 (back).



Read the PRIVACY ACT STATEMENT on reverse before completing this application

APPLICATION FOR CONSTRUCTION EQUIPMENT OPERATOR LICENSE

NAVFAC 11260/1 (REV. 6/76)

S/N 0406-LF-012-0006

PART 1 - APPLICATION

1. NAVAL ACTIVITY	2. APPLICANT'S NAME	3. RANK, RATE OR CIVILIAN STATUS

4. DEPARTMENT, DIVISION AND/OR SHOP ASSIGNED TO	5. APPLICANT'S JOB TITLE

6. DESCRIPTION OF EQUIPMENT LICENSE REQUESTED

(a) TYPE OF EQUIPMENT	(b) TYPE OF CONTROL	(c) TYPE OF ATTACHMENT

7. STATEMENT OF QUALIFYING EXPERIENCE

8. DESCRIPTION OF EQUIPMENT APPLICANT IS CURRENTLY LICENSED TO OPERATE

9. SPONSOR'S STATEMENT OF APPLICANT'S READINESS AND/OR PREPARATORY TRAINING FOR TEST (*NOTE: The sponsor can be either a qualified instructor or licensed operator)*

Signature ______________________

Sponsor

PART II - REQUEST FOR ADMINISTERING TESTS AND EXAMINATIONS AND ISSUING LICENSE

FROM: DATE:

TO:

It is requested that the license for equipment described in item 6 above be issued to this applicant upon his successful completion of the required examinations and test.

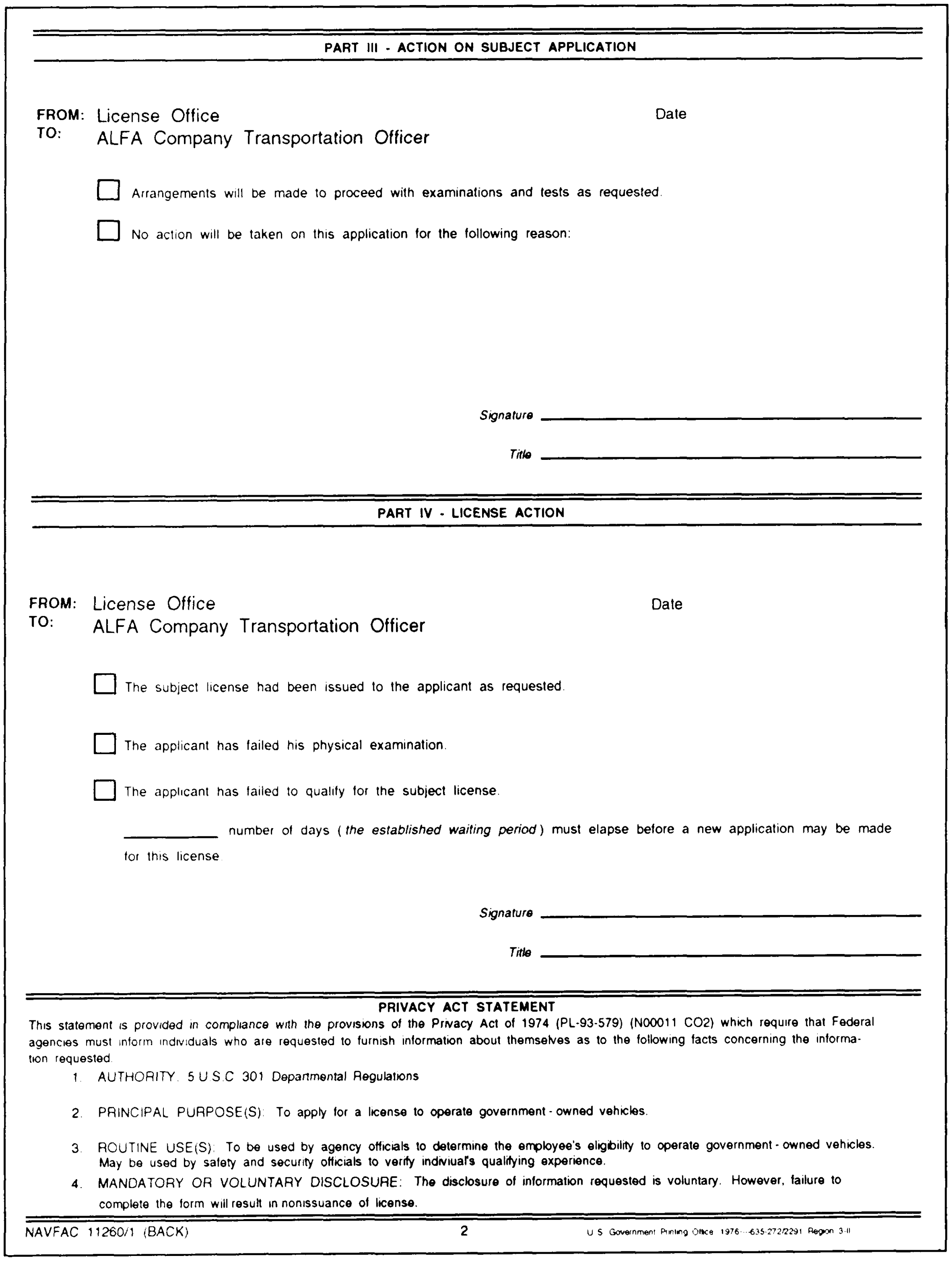
Signature ______________________

Title ______________________

Department, Division or Shop Supervisor

(OVER)

Figure 6-2A.-Application for Construction Equipment Operator License, NAVFAC 11260/1 (front).



PART III - ACTION ON SUBJECT APPLICATION

FROM: License Office Date
TO: ALFA Company Transportation Officer

☐ Arrangements will be made to proceed with examinations and tests as requested.

☐ No action will be taken on this application for the following reason:

Signature ____________________

Title ____________________

PART IV - LICENSE ACTION

FROM: License Office Date
TO: ALFA Company Transportation Officer

☐ The subject license had been issued to the applicant as requested.

☐ The applicant has failed his physical examination.

☐ The applicant has failed to qualify for the subject license.

__________ number of days (*the established waiting period*) must elapse before a new application may be made for this license.

Signature ____________________

Title ____________________

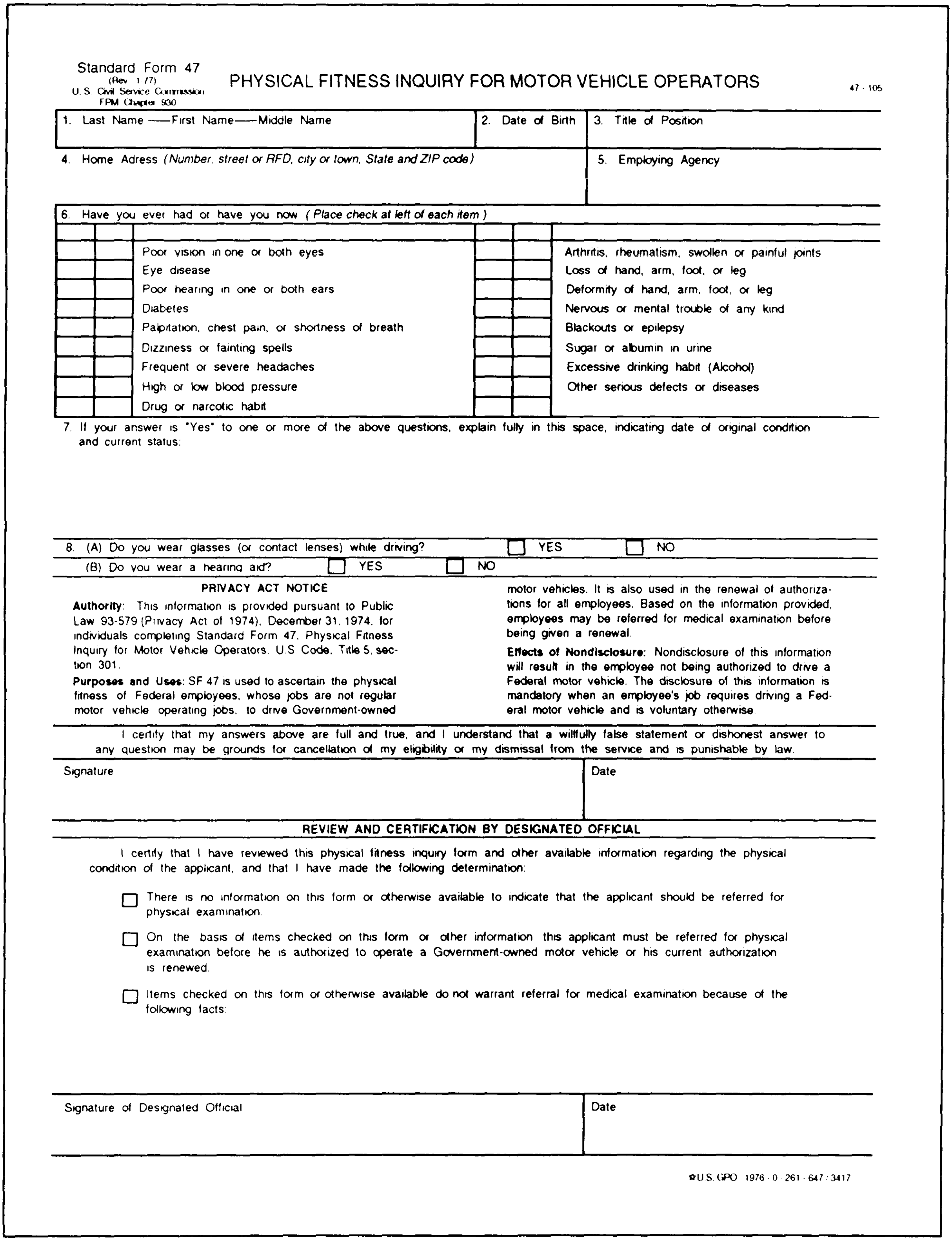
PRIVACY ACT STATEMENT

This statement is provided in compliance with the provisions of the Privacy Act of 1974 (PL-93-579) (N00011 CO2) which require that Federal agencies must inform individuals who are requested to furnish information about themselves as to the following facts concerning the information requested.

1. AUTHORITY: 5 U.S.C 301 Departmental Regulations
2. PRINCIPAL PURPOSE(S): To apply for a license to operate government-owned vehicles.
3. ROUTINE USE(S): To be used by agency officials to determine the employee's eligibility to operate government-owned vehicles. May be used by safety and security officials to verify indiviual's qualifying experience.
4. MANDATORY OR VOLUNTARY DISCLOSURE: The disclosure of information requested is voluntary. However, failure to complete the form will result in nonissuance of license.

NAVFAC 11260/1 (BACK) 2 U S Government Printing Office 1976---635-272/2291 Region 3-II

Figure 6-2B.-Application for Construction Equipment Operator License, NAVFAC 11260/1 (back).



Standard Form 47
(Rev 1-77)
U.S. Civil Service Commission
FPM Chapter 930

PHYSICAL FITNESS INQUIRY FOR MOTOR VEHICLE OPERATORS

47-105

1. Last Name ——First Name——Middle Name	2. Date of Birth	3. Title of Position

4. Home Adress *(Number, street or RFD, city or town, State and ZIP code)*	5. Employing Agency

6. Have you ever had or have you now *(Place check at left of each item)*

- ☐ ☐ Poor vision in one or both eyes
- ☐ ☐ Eye disease
- ☐ ☐ Poor hearing in one or both ears
- ☐ ☐ Diabetes
- ☐ ☐ Palpitation, chest pain, or shortness of breath
- ☐ ☐ Dizziness or fainting spells
- ☐ ☐ Frequent or severe headaches
- ☐ ☐ High or low blood pressure
- ☐ ☐ Drug or narcotic habit
- ☐ ☐ Arthritis, rheumatism, swollen or painful joints
- ☐ ☐ Loss of hand, arm, foot, or leg
- ☐ ☐ Deformity of hand, arm, foot, or leg
- ☐ ☐ Nervous or mental trouble of any kind
- ☐ ☐ Blackouts or epilepsy
- ☐ ☐ Sugar or albumin in urine
- ☐ ☐ Excessive drinking habit (Alcohol)
- ☐ ☐ Other serious defects or diseases

7. If your answer is "Yes" to one or more of the above questions, explain fully in this space, indicating date of original condition and current status:

8. (A) Do you wear glasses (or contact lenses) while driving? ☐ YES ☐ NO

(B) Do you wear a hearing aid? ☐ YES ☐ NO

PRIVACY ACT NOTICE

Authority: This information is provided pursuant to Public Law 93-579 (Privacy Act of 1974), December 31, 1974, for individuals completing Standard Form 47, Physical Fitness Inquiry for Motor Vehicle Operators. U.S. Code, Title 5, section 301.

Purposes and Uses: SF 47 is used to ascertain the physical fitness of Federal employees, whose jobs are not regular motor vehicle operating jobs, to drive Government-owned motor vehicles. It is also used in the renewal of authorizations for all employees. Based on the information provided, employees may be referred for medical examination before being given a renewal.

Effects of Nondisclosure: Nondisclosure of this information will result in the employee not being authorized to drive a Federal motor vehicle. The disclosure of this information is mandatory when an employee's job requires driving a Federal motor vehicle and is voluntary otherwise.

I certify that my answers above are full and true, and I understand that a willfully false statement or dishonest answer to any question may be grounds for cancellation of my eligibility or my dismissal from the service and is punishable by law.

Signature	Date

REVIEW AND CERTIFICATION BY DESIGNATED OFFICIAL

I certify that I have reviewed this physical fitness inquiry form and other available information regarding the physical condition of the applicant, and that I have made the following determination:

☐ There is no information on this form or otherwise available to indicate that the applicant should be referred for physical examination.

☐ On the basis of items checked on this form or other information this applicant must be referred for physical examination before he is authorized to operate a Government-owned motor vehicle or his current authorization is renewed.

☐ Items checked on this form or otherwise available do not warrant referral for medical examination because of the following facts:

Signature of Designated Official	Date

☆U.S. GPO 1976-0-261-647/3417

Figure 6-3.—Physical Fitness Inquiry for Motor Vehicle Operators, Standard Form 47.

library. This library is normally located in the mechanic shop.

Examinations and tests for military personnel applying for a license to operate general-purpose vehicles up to 10,000 pounds GVW are normally waived if the applicant possesses a valid state operator's license for the type vehicle involved.

Performance Qualification Test

All performance qualification tests on equipment, except for cranes, are given by the license examiner. This test enables the license examiner to evaluate the operating skills of each applicant. The applicant must successfully pass an operational performance or road test and perform pre- and post-operator maintenance, as outlined in the operator's manual.

The examiner should terminate any performance test that becomes hazardous or when an applicant demonstrates a lack of skill, undue nervousness, speeding, inattentiveness, or any unfavorable actions. Any reason for failure is noted on the application and filed in the license file of the applicant.

Automotive Test

Applicants for a U.S. Government Motor Vehicle Operator's Identification Card, OF-346, must pass a locally created driver skill test. This test is a locally devised checklist used to determine the reaction of the applicant under various traffic conditions. The road test is administered in the largest capacity vehicle for which the license is to be issued.

Material-Handling Equipment Test

Applicants for material-handling equipment (MHE) licenses are operationally tested and scored as prescribed in *Storage and Materials Handling*, DODINST 4145.19-R-1.

Construction Equipment Test

Applicants for a Construction Equipment Operator License, NAVFAC 11260/2, must be familiar with the standard Navy hand signals before taking a performance qualification test. Hand signals are shown in appendix IV of this TRAMAN.

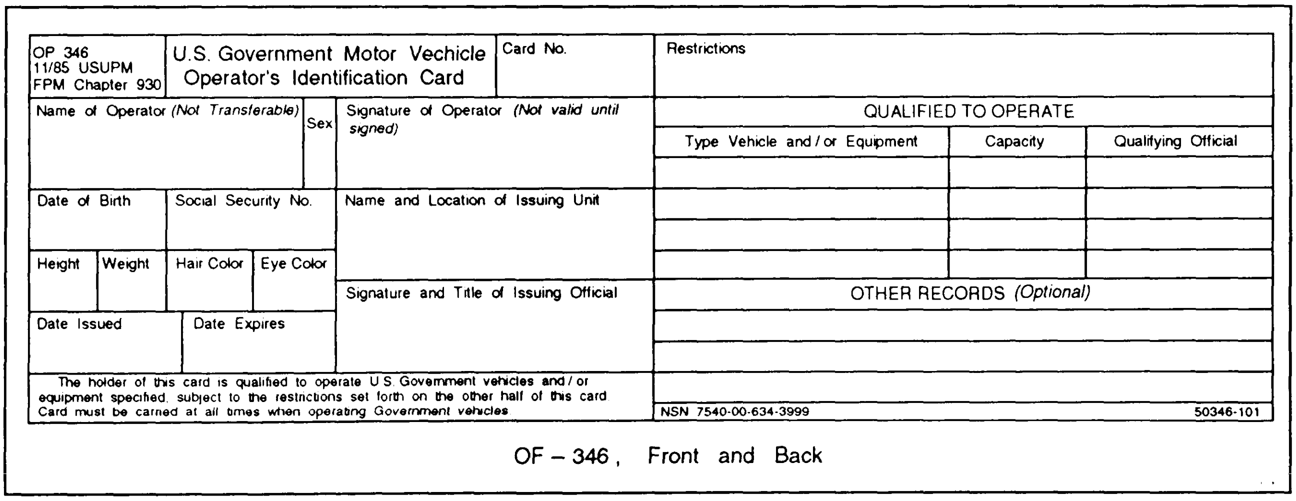
LICENSE FORMS

After an applicant satisfactorily completes the required tests, the examiner issues a license that lists each type of vehicle the license holder is authorized to operate, plus any restrictions imposed on the license.

U.S. Government Motor Vehicle Operator's Identification Card, OF-346

The OF-346 (fig. 6-4) is the license required for automotive motor vehicles and material-handling equipment. The information on an OF-346, that has been completed and validated properly, consists of the following: a card number, a list of the operator's physical limitations or restrictions, a description of the equipment the operator is qualified to operate, the signature of the examiner, the operator's signature, and any specific notations. The OF-346 expires on the birth date of the operator and is valid for 3 years.

The OF-346 card number is also indicated on the Operator's Record, NAVFAC 11240/10, or NAVFAC



OP 346
11/85 USUPM
FPM Chapter 930

U.S. Government Motor Vechicle
Operator's Identification Card

Card No.

Name of Operator *(Not Transferable)*

Sex

Signature of Operator *(Not valid until signed)*

Date of Birth

Social Security No.

Name and Location of Issuing Unit

Height

Weight

Hair Color

Eye Color

Signature and Title of Issuing Official

Date Issued

Date Expires

The holder of this card is qualified to operate U.S. Government vehicles and / or equipment specified, subject to the restrictions set forth on the other half of this card. Card must be carried at all times when operating Government vehicles.

Restrictions

QUALIFIED TO OPERATE

Type Vehicle and / or Equipment	Capacity	Qualifying Official

OTHER RECORDS *(Optional)*

NSN 7540-00-634-3999

50346-101

OF – 346, Front and Back

Figure 6-4.-U.S. Government Motor Vehicle Operator's Identification Card, OF-346.

11260/3, Construction Equipment Operator License Record (fig. 6-5). The license examiner maintains a chronological record of all licenses issued.

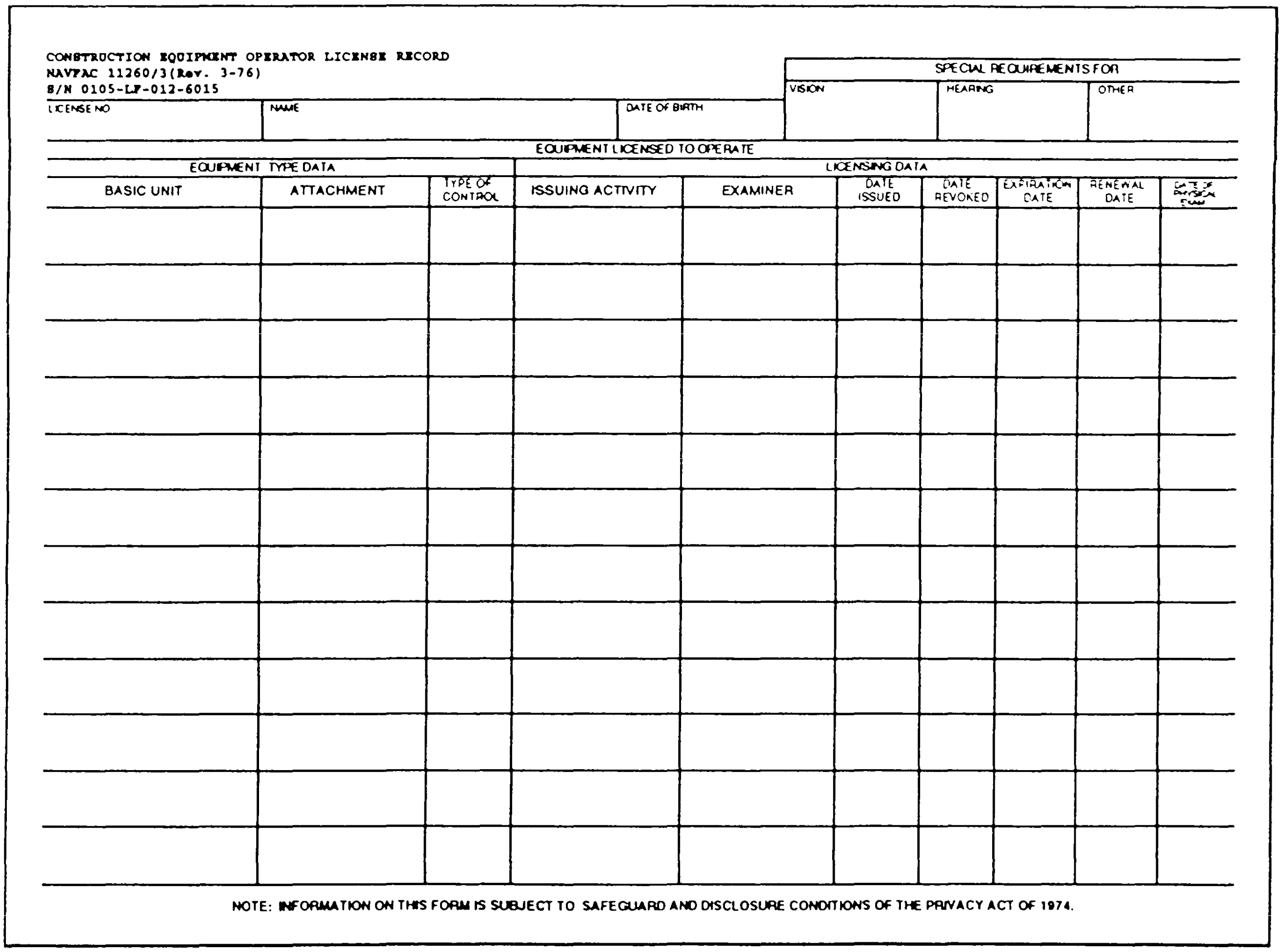
Construction Equipment Operator License, NAVFAC 11260/2

The NAVFAC 11260/2 (fig. 6-6) is the license required for operating construction equipment. The information on a NAVFAC 11260/2, that has been completed and validated properly, consists of the following: a card number, the operator's name. a description of the equipment, the make and model of the equipment, types of controls, the examiner's signature, and the operator's signature. The NAVFAC 11260/2 expires on the birth date of the operator and is valid for 2 years.

DISPATCH FORMS

Forms used for records and reports are tools used to manage an equipment pool efficiently. When properly used, these forms document the miles, hours, maintenance Performed, equipment troubles, operator names, and so forth. As the operator, you are responsible for turning in all-related dispatch forms given to you, filled out properly and legibly.

The NAVFAC 9-11240/13 and NAVFAC 11260/4 are essential parts of the equipment maintenance program. The operator of equipment has a better opportunity than anyone else to discover defects before they become serious. Reporting these defects on the proper forms gives maintenance shop personnel a chance to correct them; therefore, you should always report any operating difficulty encountered during your daily operations with vehicles and equipment.



CONSTRUCTION EQUIPMENT OPERATOR LICENSE RECORD
NAVFAC 11260/3(Rev. 3-76)
S/N 0105-LF-012-6015

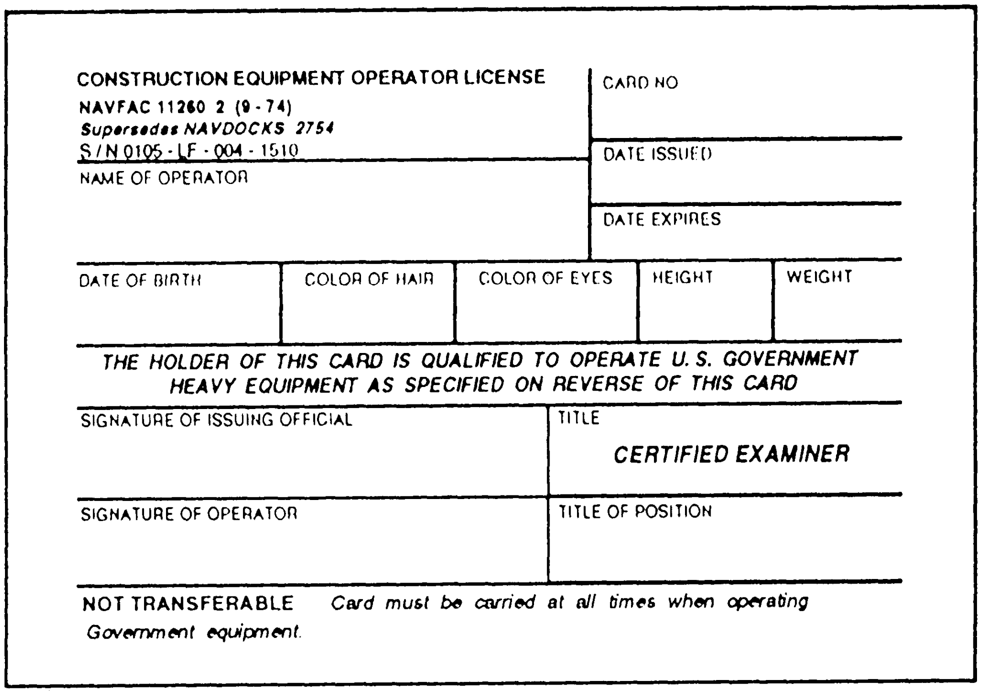
LICENSE NO	NAME	DATE OF BIRTH	SPECIAL REQUIREMENTS FOR VISION	 HEARING	 OTHER

EQUIPMENT LICENSED TO OPERATE

EQUIPMENT TYPE DATA			LICENSING DATA						
BASIC UNIT	ATTACHMENT	TYPE OF CONTROL	ISSUING ACTIVITY	EXAMINER	DATE ISSUED	DATE REVOKED	EXPIRATION DATE	RENEWAL DATE	DATE OF PHYSICAL EXAM

NOTE: INFORMATION ON THIS FORM IS SUBJECT TO SAFEGUARD AND DISCLOSURE CONDITIONS OF THE PRIVACY ACT OF 1974.

Figure 6-5.-Construction Equipment Operator License Record, NAVFAC 11260/3.



CONSTRUCTION EQUIPMENT OPERATOR LICENSE
NAVFAC 11260 2 (9-74)
Supersedes NAVDOCKS 2754
S/N 0105-LF-004-1510

NAME OF OPERATOR

CARD NO

DATE ISSUED

DATE EXPIRES

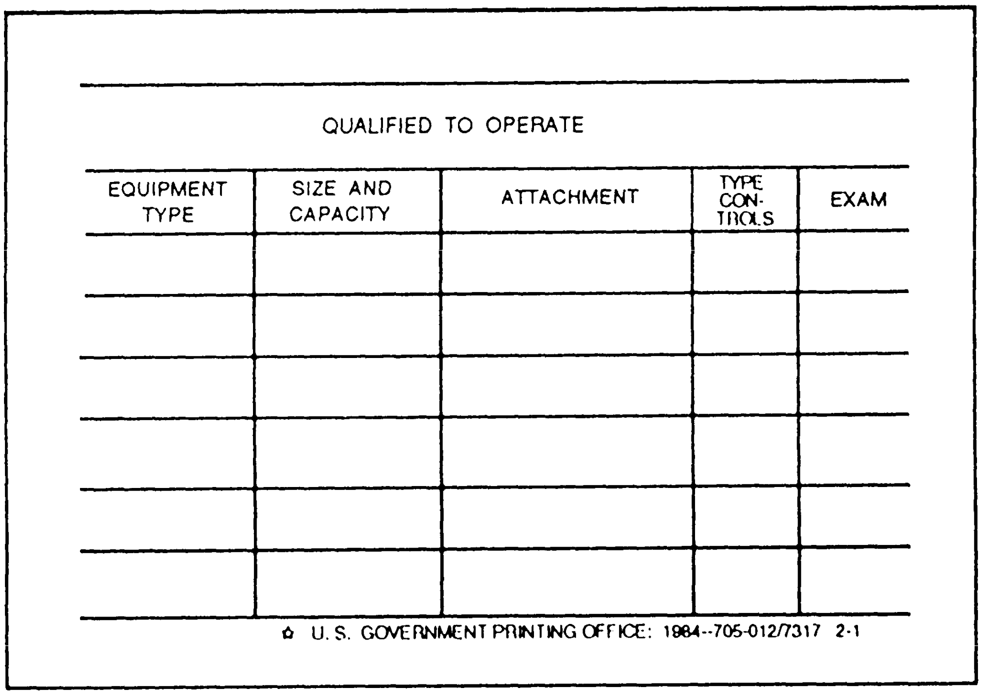
DATE OF BIRTH	COLOR OF HAIR	COLOR OF EYES	HEIGHT	WEIGHT

THE HOLDER OF THIS CARD IS QUALIFIED TO OPERATE U. S. GOVERNMENT HEAVY EQUIPMENT AS SPECIFIED ON REVERSE OF THIS CARD

SIGNATURE OF ISSUING OFFICIAL	TITLE *CERTIFIED EXAMINER*
SIGNATURE OF OPERATOR	TITLE OF POSITION

NOT TRANSFERABLE *Card must be carried at all times when operating Government equipment.*

(Front)



QUALIFIED TO OPERATE

EQUIPMENT TYPE	SIZE AND CAPACITY	ATTACHMENT	TYPE CON-TROLS	EXAM

✩ U. S. GOVERNMENT PRINTING OFFICE: 1984--705-012/7317 2-1

(Back)

Figure 6-6.-Construction Equipment Operator License, NAVFAC 11260/2.

NAVFAC 9-11240/13

The Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13 (fig. 6-7), commonly known as the **Hard Card,** is a guide for operator's maintenance. This is one of the forms used to document problems you may encounter during pre- and post-operations. This form provides a uniform list of services to be performed by the operator before, during, and after operation.

The operator indicates by a check mark any item that does not function properly. The Remarks space may be used for items not listed or for additional information concerning deficiencies indicated by a check mark. This form must be completed properly and turned into the dispatcher, who determines if the vehicle is ready for another job or that repair work is required. Your unit will have a procedure to process the Hard Card in case the vehicle needs repairs.

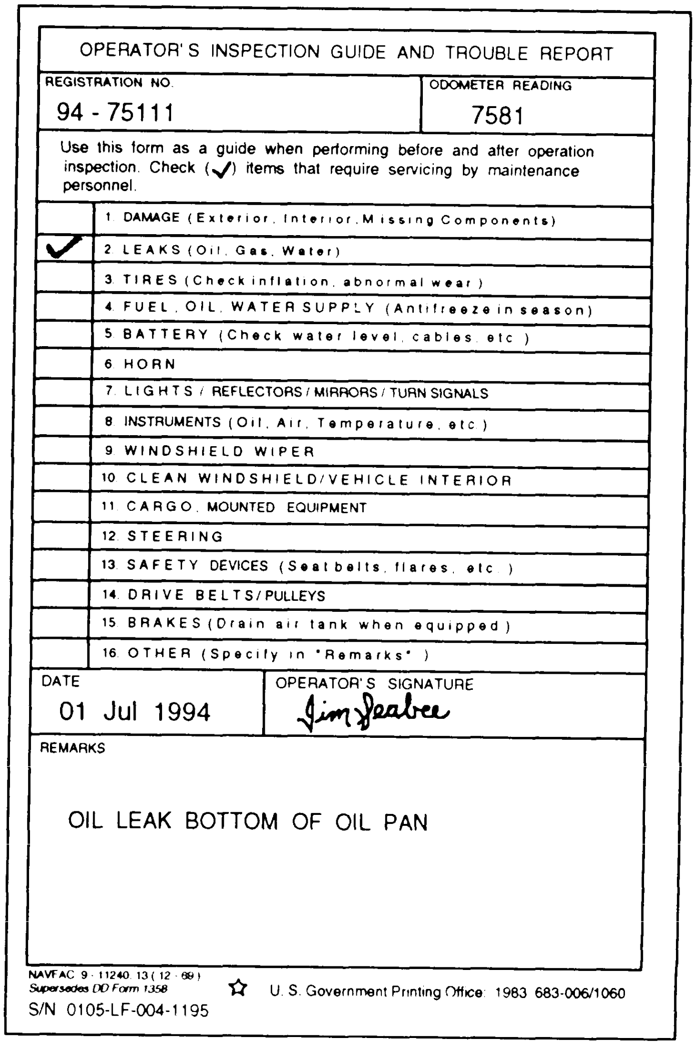
NAVFAC 11260/4

The Operator's Daily PM Report, NAVFAC 11260/4 (fig. 6-8), is issued to the operator when construction equipment is used. You will perform prestart maintenance checks of the items listed and indicate findings in the appropriate space on the NAVFAC 11260/4. Record malfunctions or other items requiring attention as observed during the working day, and enter hours operated during the day. Hour readings are taken from the equipment hour meter. After securing the equipment, take the NAVFAC 11260/4 to the dispatcher. The dispatcher will review the report to ensure recorded entries are valid and will take note of any deficiencies.

DD FORM 1970

When filled out and signed properly by the dispatcher and operator, the Motor Vehicle Utilization Record, DD Form 1970 (fig. 6-9), is an operator's official authorization to operate a vehicle whether it be driven by the requester or driven by a pool operator. This form, commonly known as the **Trip Ticket,** is a record to verify the vehicle was on an official trip; therefore, it should be filled out properly and signed. When completed properly, a trip ticket contains a record of the operator's destination, time of departure and arrival, speedometer reading, and other information pertinent to the trip(s).

NOTE: If the speedometer is broken, the operator must estimate the amount of miles traveled.



OPERATOR'S INSPECTION GUIDE AND TROUBLE REPORT

REGISTRATION NO. 94 - 75111	ODOMETER READING 7581

Use this form as a guide when performing before and after operation inspection. Check (✓) items that require servicing by maintenance personnel.

	1 DAMAGE (Exterior, Interior, Missing Components)
✓	2 LEAKS (Oil, Gas, Water)
	3 TIRES (Check inflation, abnormal wear)
	4 FUEL, OIL, WATER SUPPLY (Antifreeze in season)
	5 BATTERY (Check water level, cables, etc.)
	6 HORN
	7 LIGHTS / REFLECTORS / MIRRORS / TURN SIGNALS
	8 INSTRUMENTS (Oil, Air, Temperature, etc.)
	9 WINDSHIELD WIPER
	10 CLEAN WINDSHIELD/VEHICLE INTERIOR
	11 CARGO, MOUNTED EQUIPMENT
	12 STEERING
	13 SAFETY DEVICES (Seat belts, flares, etc.)
	14 DRIVE BELTS/PULLEYS
	15 BRAKES (Drain air tank when equipped)
	16 OTHER (Specify in "Remarks")

DATE 01 Jul 1994	OPERATOR'S SIGNATURE Jim Seabee

REMARKS

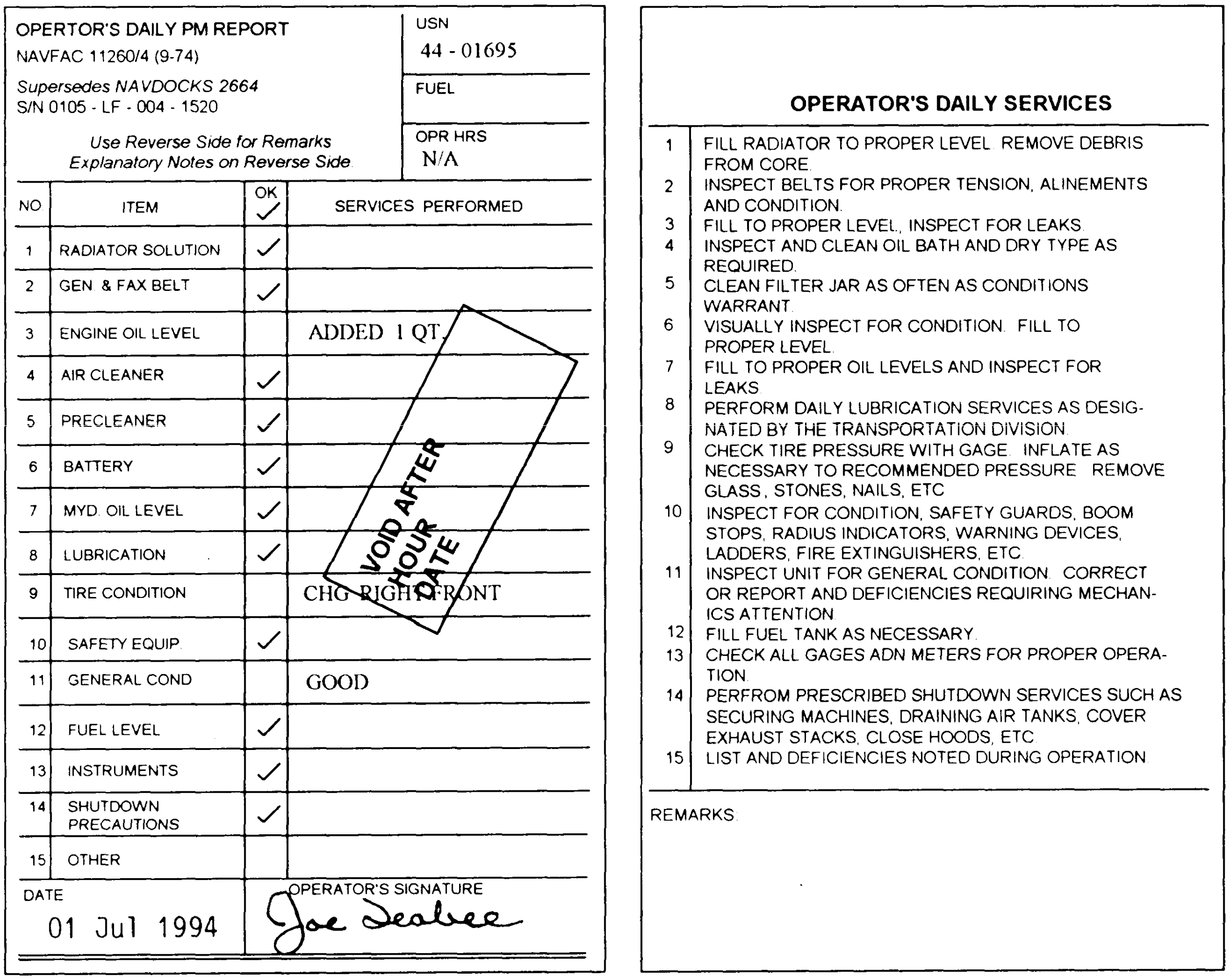
OIL LEAK BOTTOM OF OIL PAN

NAVFAC 9-11240.13 (12-69)
Supersedes DD Form 1358
S/N 0105-LF-004-1195
☆ U. S. Government Printing Office: 1983 683-006/1060

Figure 6-7.-Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13.

STANDARD FORM 91

Every mishap involving a Navy motor vehicle or item of construction equipment must be reported on an Operator's Report of Motor Vehicle Accident, Standard Form 91 (figs. 6-10A and 6-10B). Copies of the SF 91, mishap instructions, and a pencil should be carried in every Navy vehicle at all times. In case of a mishap involving another vehicle, this report must be completed. This is true even if the driver of the other vehicle states that no claim will be filed for damages or no matter how unfavorable the circumstances of the mishap may appear to the Navy. The report must also be completed for a mishap not involving another vehicle. The operator involved in a mishap must deliver the mishap report or ensure its immediate delivery, as soon as possible, to the supervisor, who must forward it to the battalion mishap investigator.



OPERTOR'S DAILY PM REPORT
NAVFAC 11260/4 (9-74)
Supersedes NAVDOCKS 2664
S/N 0105 - LF - 004 - 1520

Use Reverse Side for Remarks
Explanatory Notes on Reverse Side

USN: 44 - 01695
FUEL:
OPR HRS: N/A

NO	ITEM	OK ✓	SERVICES PERFORMED
1	RADIATOR SOLUTION	✓	
2	GEN & FAX BELT	✓	
3	ENGINE OIL LEVEL		ADDED 1 QT
4	AIR CLEANER	✓	
5	PRECLEANER	✓	
6	BATTERY	✓	
7	MYD OIL LEVEL	✓	
8	LUBRICATION	✓	
9	TIRE CONDITION		CHG RIGHT FRONT
10	SAFETY EQUIP	✓	
11	GENERAL COND		GOOD
12	FUEL LEVEL	✓	
13	INSTRUMENTS	✓	
14	SHUTDOWN PRECAUTIONS	✓	
15	OTHER		

VOID AFTER HOUR DATE

DATE: 01 Jul 1994
OPERATOR'S SIGNATURE: Joe Seabee

(FRONT)

OPERATOR'S DAILY SERVICES

1 FILL RADIATOR TO PROPER LEVEL REMOVE DEBRIS FROM CORE
2 INSPECT BELTS FOR PROPER TENSION, ALINEMENTS AND CONDITION.
3 FILL TO PROPER LEVEL, INSPECT FOR LEAKS
4 INSPECT AND CLEAN OIL BATH AND DRY TYPE AS REQUIRED.
5 CLEAN FILTER JAR AS OFTEN AS CONDITIONS WARRANT
6 VISUALLY INSPECT FOR CONDITION. FILL TO PROPER LEVEL
7 FILL TO PROPER OIL LEVELS AND INSPECT FOR LEAKS
8 PERFORM DAILY LUBRICATION SERVICES AS DESIGNATED BY THE TRANSPORTATION DIVISION
9 CHECK TIRE PRESSURE WITH GAGE. INFLATE AS NECESSARY TO RECOMMENDED PRESSURE REMOVE GLASS, STONES, NAILS, ETC
10 INSPECT FOR CONDITION, SAFETY GUARDS, BOOM STOPS, RADIUS INDICATORS, WARNING DEVICES, LADDERS, FIRE EXTINGUISHERS, ETC
11 INSPECT UNIT FOR GENERAL CONDITION CORRECT OR REPORT AND DEFICIENCIES REQUIRING MECHANICS ATTENTION
12 FILL FUEL TANK AS NECESSARY
13 CHECK ALL GAGES ADN METERS FOR PROPER OPERATION
14 PERFROM PRESCRIBED SHUTDOWN SERVICES SUCH AS SECURING MACHINES, DRAINING AIR TANKS, COVER EXHAUST STACKS, CLOSE HOODS, ETC
15 LIST AND DEFICIENCIES NOTED DURING OPERATION

REMARKS

(BACK)

Figure 6-8.-Operator's Daily PM Report, NAVFAC 11260/4.

If involved in a mishap, your first responsibility is to render aid to the injured. After they have been cared for, complete the mishap report. As an aid in completing Standard Form 91, comply with the following instructions:

1. Obtain and properly spell names and street addresses of persons involved in the mishap and any personnel that may have witnessed the mishap.

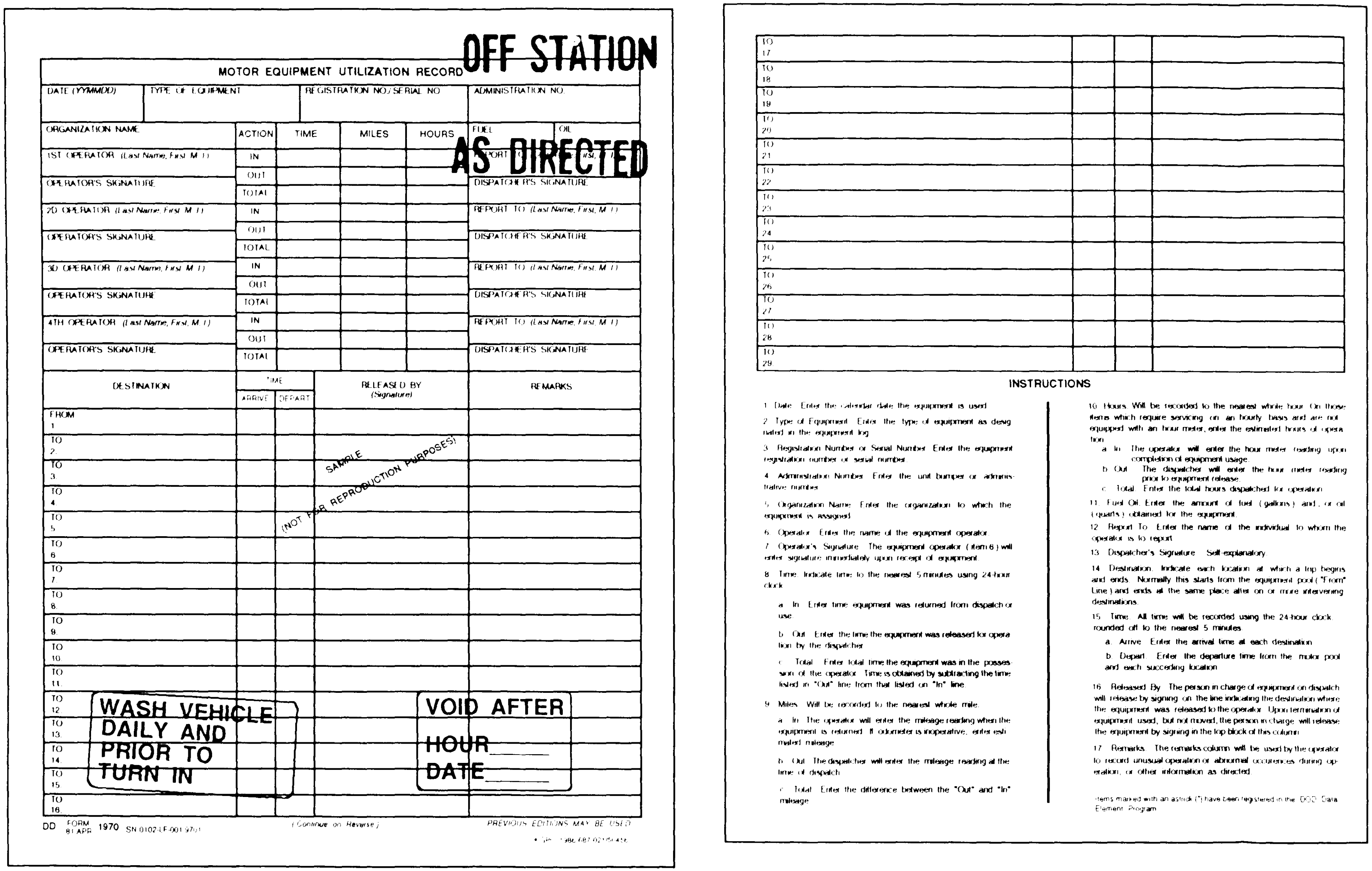
2. Carefully note weather conditions, road conditions, position of the vehicle involved, and other details, which you will not be able to get later.

3. Be sure that your report gives a clear picture of what actually happened. Your diagram of the mishap should show exactly where the vehicles were before and after the mishap.

4. State damage you can see, such as “crushed right rear wheel or crumpled fender,” and give an estimate of the amount of damage. If someone claims that he or she has damaged property but you cannot see the damage, note on the accident form only that he or she “claims bent fender,” and so forth. Follow the same procedures with injuries. Report cuts, burns, broken bones, and so forth, of which you are certain, and note only that a person “claims” an injury when you have no way of knowing the truth. If you cannot get the exact information on some item, write “unknown” to show that you did not overlook it.

5. When sufficient space is not available for providing information regarding an item, write “see attached sheet,” and attach an extra sheet containing the additional information on that item.

6. After you have finished your report, look it over carefully and ensure it is complete and accurate. If you are satisfied, sign the report, and take it to the mishap investigator.



OFF STATION

MOTOR EQUIPMENT UTILIZATION RECORD

DATE (YYMMDD) | TYPE OF EQUIPMENT | REGISTRATION NO./SERIAL NO. | ADMINISTRATION NO.

ORGANIZATION NAME	ACTION	TIME	MILES	HOURS	FUEL	OIL
1ST OPERATOR (Last Name, First, M I)	IN				REPORT TO (Last Name, First, M I)	
	OUT					
OPERATOR'S SIGNATURE	TOTAL				DISPATCHER'S SIGNATURE	
2D OPERATOR (Last Name, First, M I)	IN				REPORT TO (Last Name, First, M I)	
	OUT					
OPERATOR'S SIGNATURE	TOTAL				DISPATCHER'S SIGNATURE	
3D OPERATOR (Last Name, First, M I)	IN				REPORT TO (Last Name, First, M I)	
	OUT					
OPERATOR'S SIGNATURE	TOTAL				DISPATCHER'S SIGNATURE	
4TH OPERATOR (Last Name, First, M I)	IN				REPORT TO (Last Name, First, M I)	
	OUT					
OPERATOR'S SIGNATURE	TOTAL				DISPATCHER'S SIGNATURE	

AS DIRECTED

DESTINATION	TIME		RELEASED BY (Signature)	REMARKS
	ARRIVE	DEPART		
FROM 1				
TO 2				
TO 3				
TO 4				
TO 5				
TO 6				
TO 7				
TO 8				
TO 9				
TO 10				
TO 11				
TO 12				
TO 13				
TO 14				
TO 15				
TO 16				

SAMPLE (NOT FOR REPRODUCTION PURPOSES)

WASH VEHICLE DAILY AND PRIOR TO TURN IN

VOID AFTER
HOUR______
DATE______

DD FORM 81 APR 1970 SN 0102-LF-001-9701 (Continue on Reverse) PREVIOUS EDITIONS MAY BE USED

• GPO : 1986 687-021/50456

Motor Vehicle Utilization Record, DD Form 1970 (front)

TO 17			
TO 18			
TO 19			
TO 20			
TO 21			
TO 22			
TO 23			
TO 24			
TO 25			
TO 26			
TO 27			
TO 28			
TO 29			

INSTRUCTIONS

1 Date Enter the calendar date the equipment is used

2 Type of Equipment Enter the type of equipment as designated in the equipment log

3 Registration Number or Serial Number Enter the equipment registration number or serial number.

4 Administration Number Enter the unit bumper or administrative number

5 Organization Name Enter the organization to which the equipment is assigned

6. Operator Enter the name of the equipment operator.

7 Operator's Signature The equipment operator (item 6) will enter signature immediately upon receipt of equipment.

8 Time. Indicate time to the nearest 5 minutes using 24-hour clock

a In Enter time equipment was returned from dispatch or use.

b Out Enter the time the equipment was released for operation by the dispatcher

c Total Enter total time the equipment was in the possession of the operator Time is obtained by subtracting the time listed in "Out" line from that listed on "In" line.

9 Miles Will be recorded to the nearest whole mile.

a In The operator will enter the mileage reading when the equipment is returned If odometer is inoperative, enter estimated mileage

b Out The dispatcher will enter the mileage reading at the time of dispatch

c Total Enter the difference between the "Out" and "In" mileage

10 Hours. Will be recorded to the nearest whole hour On those items which require servicing on an hourly basis and are not equipped with an hour meter, enter the estimated hours of operation

a In The operator will enter the hour meter reading upon completion of equipment usage.

b Out The dispatcher will enter the hour meter reading prior to equipment release.

c Total. Enter the total hours dispatched for operation

11. Fuel Oil. Enter the amount of fuel (gallons) and, or oil (quarts) obtained for the equipment.

12 Report To Enter the name of the individual to whom the operator is to report

13 Dispatcher's Signature Self-explanatory.

14 Destination. Indicate each location at which a trip begins and ends. Normally this starts from the equipment pool ("From" Line) and ends at the same place after on or more intervening destinations.

15 Time. All time will be recorded using the 24-hour clock. rounded off to the nearest 5 minutes.

a. Arrive Enter the arrival time at each destination

b. Depart. Enter the departure time from the motor pool and each succeding location

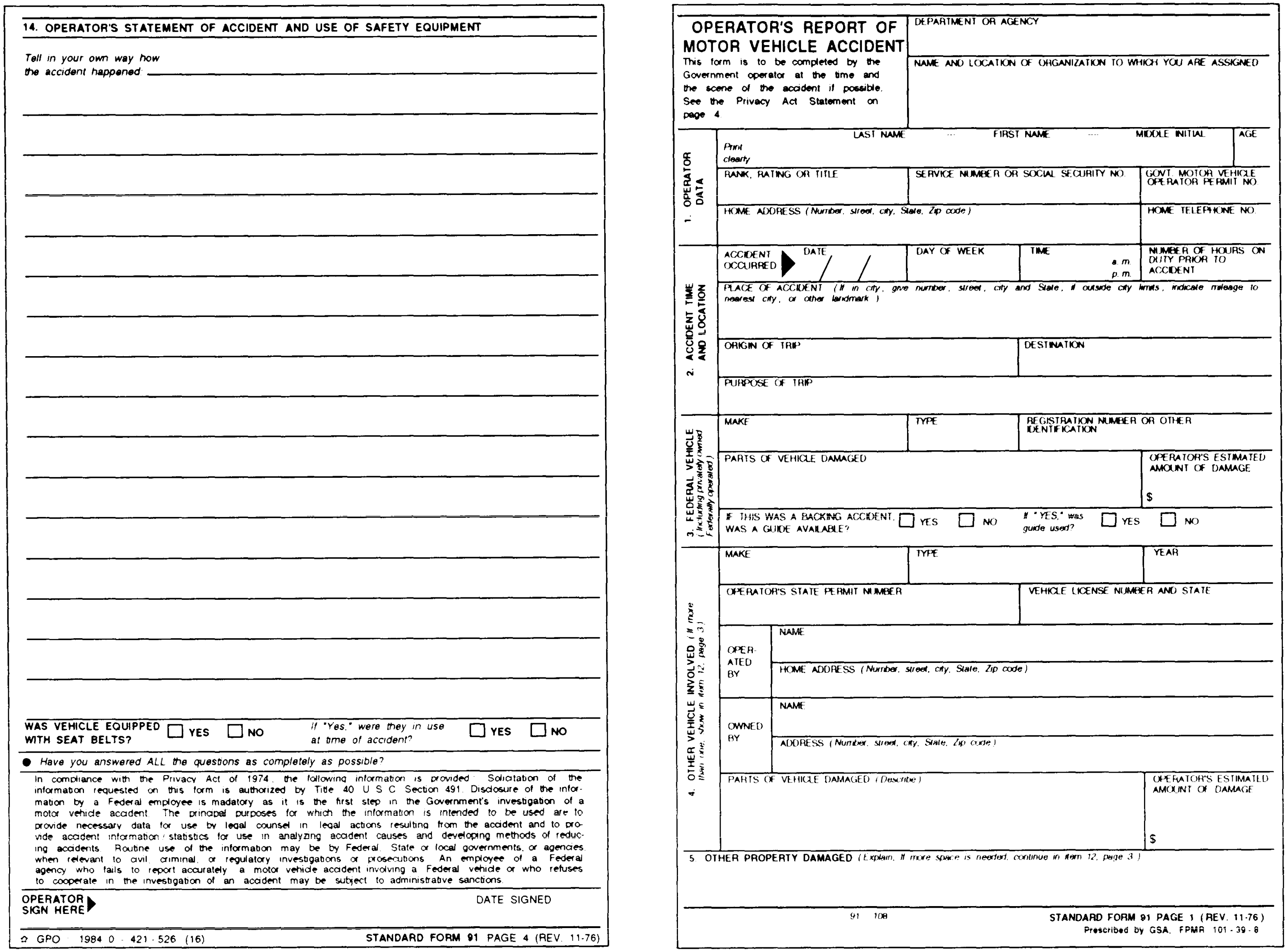
16 Released By The person in charge of equipment on dispatch will release by signing on the line indicating the destination where the equipment was released to the operator Upon termination of equipment used, but not moved, the person in charge will release the equipment by signing in the top block of this column

17 Remarks. The remarks column will be used by the operator to record unusual operation or abnormal occurences during operation, or other information as directed.

Items marked with an astrick (*) have been registered in the DOD Data Element Program

Motor Vehicle Utilization Record, DD Form 1970 (back)

Figure 6-9.—Motor Vehicle Utilization Record, DD Form 1970.



14. OPERATOR'S STATEMENT OF ACCIDENT AND USE OF SAFETY EQUIPMENT

Tell in your own way how the accident happened ____________________

WAS VEHICLE EQUIPPED WITH SEAT BELTS? ☐ YES ☐ NO *If "Yes," were they in use at time of accident?* ☐ YES ☐ NO

● *Have you answered ALL the questions as completely as possible?*

In compliance with the Privacy Act of 1974, the following information is provided: Solicitation of the information requested on this form is authorized by Title 40 U S C Section 491. Disclosure of the information by a Federal employee is madatory as it is the first step in the Government's investigation of a motor vehicle accident. The principal purposes for which the information is intended to be used are to provide necessary data for use by legal counsel in legal actions resulting from the accident and to provide accident information/statistics for use in analyzing accident causes and developing methods of reducing accidents. Routine use of the information may be by Federal, State or local governments, or agencies when relevant to civil, criminal, or regulatory investigations or prosecutions. An employee of a Federal agency who fails to report accurately a motor vehicle accident involving a Federal vehicle or who refuses to cooperate in the investigation of an accident may be subject to administrative sanctions.

OPERATOR SIGN HERE ▶ DATE SIGNED

☆ GPO 1984 0 - 421 - 526 (16) **STANDARD FORM 91** PAGE 4 (REV. 11-76)

OPERATOR'S REPORT OF MOTOR VEHICLE ACCIDENT

This form is to be completed by the Government operator at the time and the scene of the accident if possible. See the Privacy Act Statement on page 4.

DEPARTMENT OR AGENCY

NAME AND LOCATION OF ORGANIZATION TO WHICH YOU ARE ASSIGNED

1. OPERATOR DATA

Print clearly LAST NAME --- FIRST NAME ---- MIDDLE INITIAL | AGE

RANK, RATING OR TITLE | SERVICE NUMBER OR SOCIAL SECURITY NO. | GOVT. MOTOR VEHICLE OPERATOR PERMIT NO.

HOME ADDRESS (*Number, street, city, State, Zip code*) | HOME TELEPHONE NO.

2. ACCIDENT TIME AND LOCATION

ACCIDENT OCCURRED ▶ DATE / / | DAY OF WEEK | TIME a.m. p.m. | NUMBER OF HOURS ON DUTY PRIOR TO ACCIDENT

PLACE OF ACCIDENT (*If in city, give number, street, city and State, if outside city limits, indicate mileage to nearest city, or other landmark.*)

ORIGIN OF TRIP | DESTINATION

PURPOSE OF TRIP

3. FEDERAL VEHICLE (*Including privately owned Federally operated*)

MAKE | TYPE | REGISTRATION NUMBER OR OTHER IDENTIFICATION

PARTS OF VEHICLE DAMAGED | OPERATOR'S ESTIMATED AMOUNT OF DAMAGE $

IF THIS WAS A BACKING ACCIDENT, WAS A GUIDE AVAILABLE? ☐ YES ☐ NO *If "YES," was guide used?* ☐ YES ☐ NO

4. OTHER VEHICLE INVOLVED (*If more than one, show in item 12, page 3.*)

MAKE | TYPE | YEAR

OPERATOR'S STATE PERMIT NUMBER | VEHICLE LICENSE NUMBER AND STATE

OPERATED BY: NAME

HOME ADDRESS (*Number, street, city, State, Zip code*)

OWNED BY: NAME

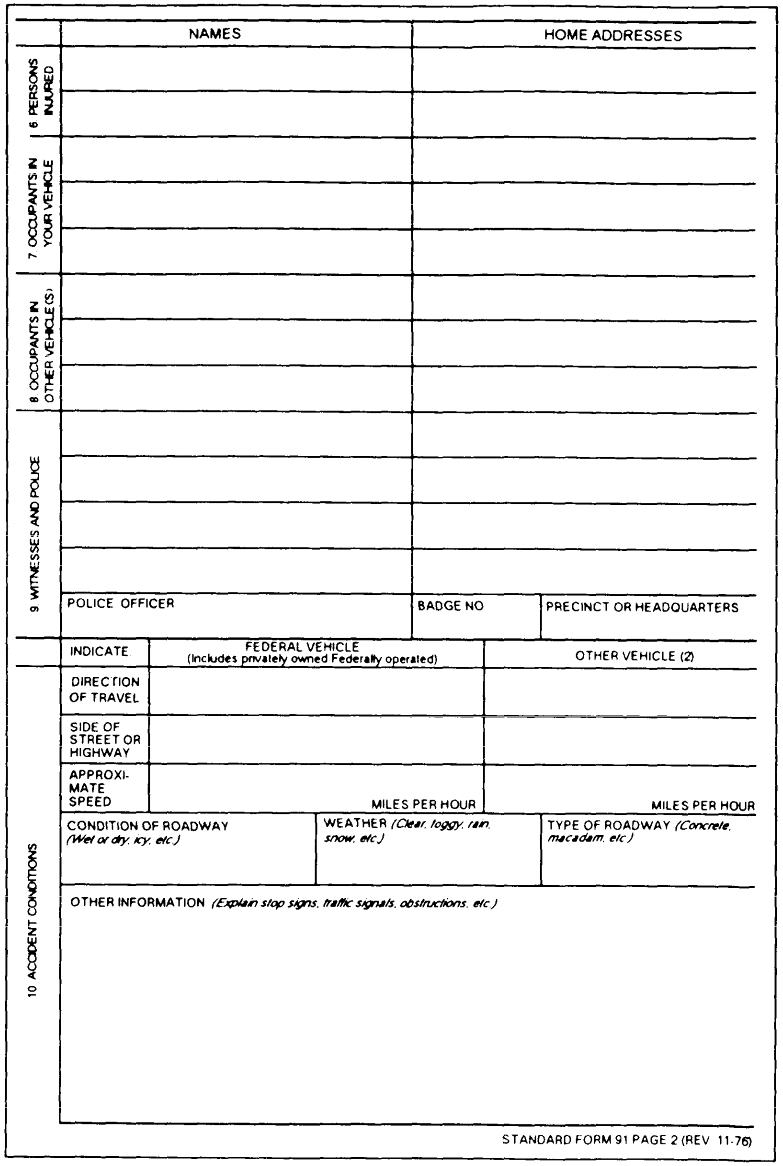
ADDRESS (*Number, street, city, State, Zip code*)

PARTS OF VEHICLE DAMAGED (*Describe*) | OPERATOR'S ESTIMATED AMOUNT OF DAMAGE $

5. **OTHER PROPERTY DAMAGED** (*Explain. If more space is needed, continue in item 12, page 3.*)

91 108 **STANDARD FORM 91 PAGE 1 (REV. 11-76)**
Prescribed by GSA, FPMR 101-39-8

Figure 6-10A.-Operator's Report of Motor Vehicle Accident, Standard Form 91 (front).



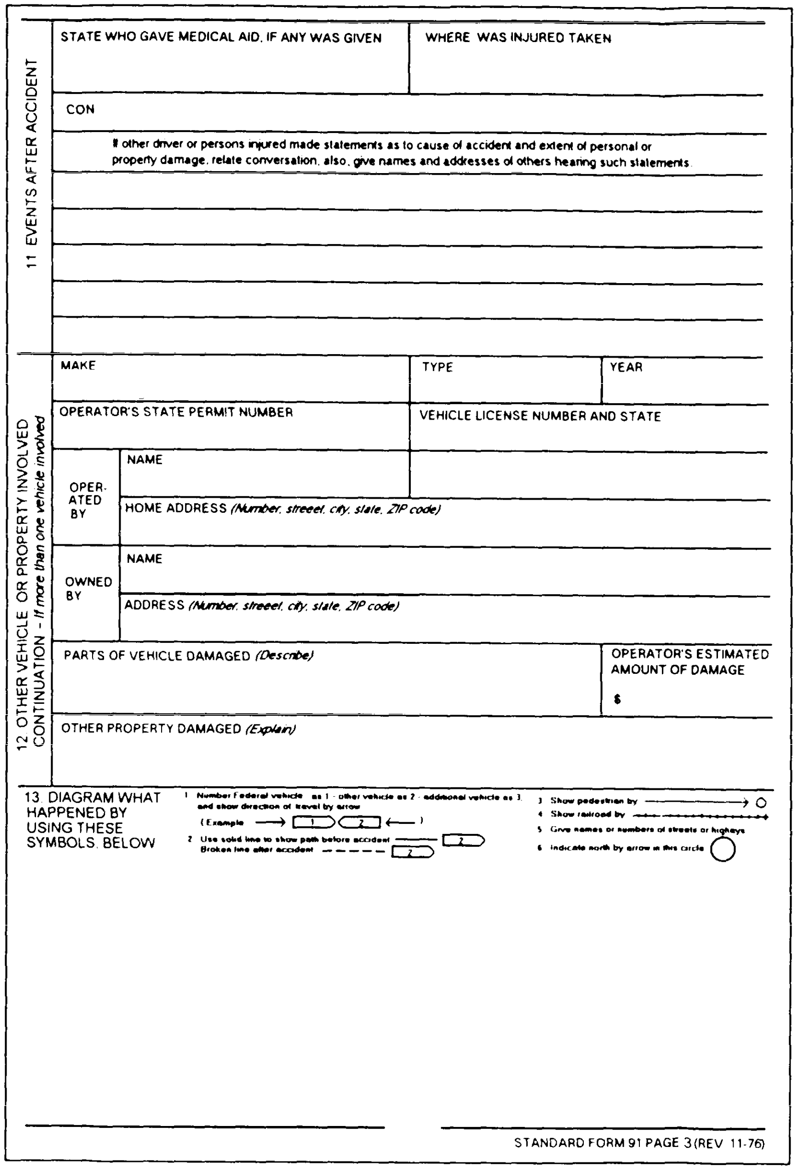
		NAMES	HOME ADDRESSES	
6 PERSONS INJURED				
7 OCCUPANTS IN YOUR VEHICLE				
8 OCCUPANTS IN OTHER VEHICLE(S)				
9 WITNESSES AND POLICE				
	POLICE OFFICER		BADGE NO	PRECINCT OR HEADQUARTERS

10 ACCIDENT CONDITIONS	INDICATE	FEDERAL VEHICLE (Includes privately owned Federally operated)	OTHER VEHICLE (2)
	DIRECTION OF TRAVEL		
	SIDE OF STREET OR HIGHWAY		
	APPROXIMATE SPEED	MILES PER HOUR	MILES PER HOUR

CONDITION OF ROADWAY *(Wet or dry, icy, etc.)*	WEATHER *(Clear, foggy, rain, snow, etc.)*	TYPE OF ROADWAY *(Concrete, macadam, etc.)*

OTHER INFORMATION *(Explain stop signs, traffic signals, obstructions, etc.)*

STANDARD FORM 91 PAGE 2 (REV 11-76)



11 EVENTS AFTER ACCIDENT

STATE WHO GAVE MEDICAL AID, IF ANY WAS GIVEN	WHERE WAS INJURED TAKEN

CON

If other driver or persons injured made statements as to cause of accident and extent of personal or property damage, relate conversation, also, give names and addresses of others hearing such statements.

12 OTHER VEHICLE OR PROPERTY INVOLVED
CONTINUATION - *If more than one vehicle involved*

MAKE		TYPE	YEAR
OPERATOR'S STATE PERMIT NUMBER		VEHICLE LICENSE NUMBER AND STATE	
OPERATED BY	NAME		
	HOME ADDRESS *(Number, street, city, state, ZIP code)*		
OWNED BY	NAME		
	ADDRESS *(Number, street, city, state, ZIP code)*		
PARTS OF VEHICLE DAMAGED *(Describe)*			OPERATOR'S ESTIMATED AMOUNT OF DAMAGE $
OTHER PROPERTY DAMAGED *(Explain)*			

13 DIAGRAM WHAT HAPPENED BY USING THESE SYMBOLS BELOW

1 Number Federal vehicle as 1 - other vehicle as 2 - additional vehicle as 3, and show direction of travel by arrow (Example ⟶ 1 2 ⟵)
2 Use solid line to show path before accident ——— 2
Broken line after accident – – – – – 2
3 Show pedestrian by ⟶ ○
4 Show railroad by
5 Give names or numbers of streets or highways
6 Indicate north by arrow in this circle ○

STANDARD FORM 91 PAGE 3 (REV 11-76)

Figure 6-10B.-Operatos's Report of Motor Vehicle Accident, Standard Form 91 (back).

DD FORM 518

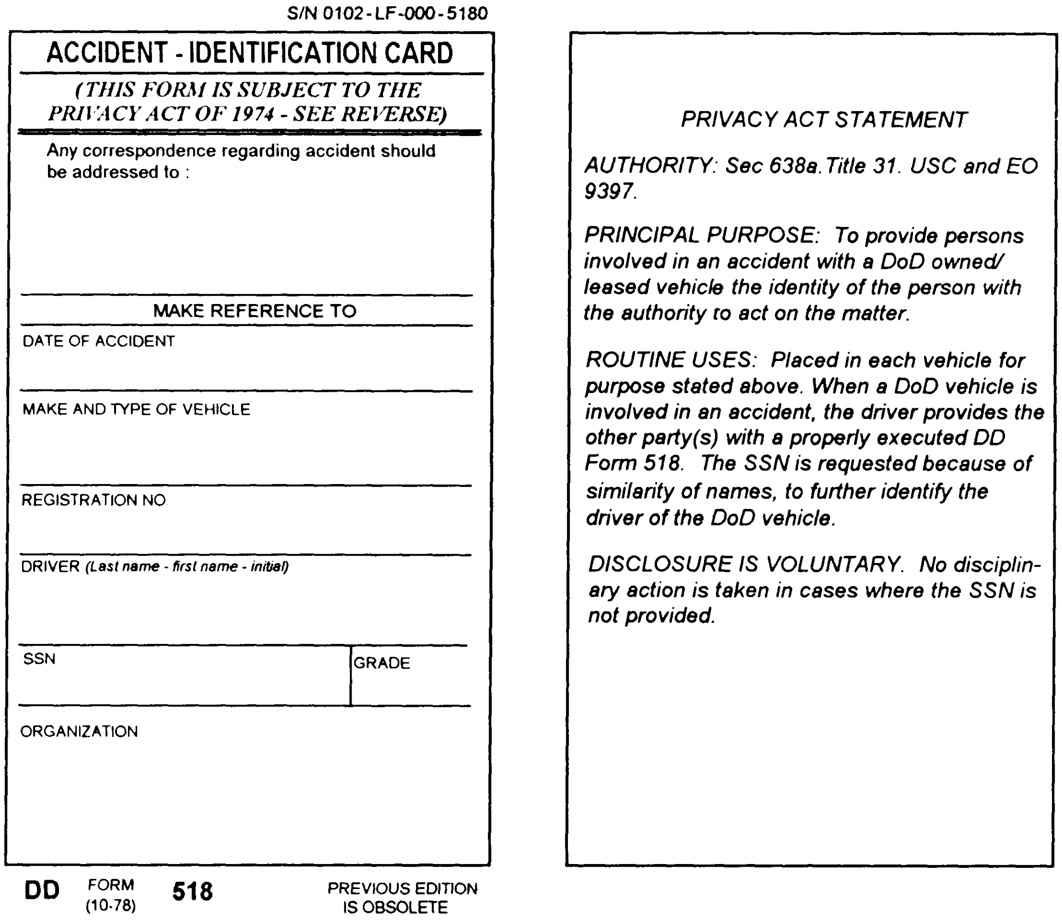
The Accident-Identification Card, DD Form 518 (fig. 6-11), is used to provide any person involved in a mishap with a Navy vehicle with the name and organizational assignment of the Navy operator. Always fill out the DD Form 518 at the scene of the mishap, and give a copy to the driver of the other vehicle concerned. If the mishap involves a parked car and the owner or operator is not available, place the DD Form 518 in or on the parked vehicle. Notify the police immediately, and remain at the scene of the mishap until the police arrive or the owner or operator can be located.

TRANSPORTATION POOL

The management, maintenance, and administration of transportation, construction, weight-handling and material-handling equipment at an activity are the responsibility of designated components, such as the transportation division, branch, or section in a Public Works Department or Alfa company in a Naval Mobile Construction Battalion (NMCB).

The transportation officer in a public works and the Alfa company commander designated as the equipment officer in an NMCB are directly responsible to the commanding officer of the activity for the management and maintenance of all assigned CESE. In an NMCB, the Alfa company operations chief, transportation supervisor, and senior petty officers are responsible to the equipment officer for the administration, operations, and operator maintenance of all assigned CESE.

YOUR PERFORMANCE when assigned as the dispatcher, yard boss, collateral equipage custodian, attachment custodian, as an EO assigned to the transportation pool, or when conducting prestarts, operating equipment, performing post-operational checks, operator's maintenance, and completing and documenting any problems with apiece of equipment is all part of the equipment management program.



S/N 0102-LF-000-5180

ACCIDENT - IDENTIFICATION CARD

(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974 - SEE REVERSE)

Any correspondence regarding accident should be addressed to :

MAKE REFERENCE TO

DATE OF ACCIDENT

MAKE AND TYPE OF VEHICLE

REGISTRATION NO

DRIVER *(Last name - first name - initial)*

SSN	GRADE

ORGANIZATION

DD FORM (10-78) 518 PREVIOUS EDITION IS OBSOLETE

(FRONT)

PRIVACY ACT STATEMENT

AUTHORITY: Sec 638a.Title 31. USC and EO 9397.

PRINCIPAL PURPOSE: To provide persons involved in an accident with a DoD owned/ leased vehicle the identity of the person with the authority to act on the matter.

ROUTINE USES: Placed in each vehicle for purpose stated above. When a DoD vehicle is involved in an accident, the driver provides the other party(s) with a properly executed DD Form 518. The SSN is requested because of similarity of names, to further identify the driver of the DoD vehicle.

DISCLOSURE IS VOLUNTARY. No disciplinary action is taken in cases where the SSN is not provided.

(BACK)

Figure 6-11.-Accident-Identification Card, DD Form 518.

DISPATCHING

Your primary duty when dispatching is to manage the assigned equipment resources efficiently within the general policies and directives of the Navy and policies set forth by the equipment officer. Policies and directives for dispatch operations are outlined in the NAVFAC P-300, *Management of Transportation;* NAVFAC P-404, *Equipment Management Manual;* and COMSECOND/COMTHIRDNCBINST 11200.1 Series, Naval Mobile Construction Battalion (NMCB) Equipment Management Instruction.

Duties of the Dispatcher

The dispatcher is the key equipment management position in a unit and is the hub of communication for daily equipment operations. A competent dispatcher must possess the knowledge, skill, and ability to accomplish the following:

- Convey information and instruction in a concise and tactful manner.
- Exercise good judgment and make decisions quickly.
- Work efficiently under pressure.
- Conduct administrative, clerical, and record-keeping duties
- Have knowledge of equipment sizes, types, uses, and limitations.

Some of the major job requirements of the dispatcher are as follows:

1. Route information: The dispatcher must know and convey to operators information on the weather, road conditions, routes to travel, and emergency procedures. The dispatcher must also know weight limits on roads and bridges, low clearances, traffic hazards, and have a good knowledge of local transportation systems, schedules, and routes.

2. Equipment status: The dispatcher must know the current status and location of every assigned item of equipment.

3. Keys: The dispatcher controls the keys to all vehicle locking devices and ignition keys. Spare keys are maintained in the equipment history jacket.

4. Records: The dispatcher checks operator licenses, and issues the Operator's Daily PM Report, NAVFAC 11260/4, for documenting pre- and post-operational checks on construction, weight-handling, and material-handling equipment. The Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13, and the Motor Equipment Utilization Record, DD Form 1970, are used for documenting pre- and post-operational checks and recording the utilization of automotive equipment. Additionally, the dispatcher must ensure that equipment required to operate over the road contains mishap reporting procedures and forms. The proper forms are a Standard Form 91 and a description of local mishap reporting procedures.

EQUIPMENT STATUS BOARD.— The Equipment Status Board provides a means of listing, by USN number, all equipment assigned to a unit. The status board should be color-coded to identify the current status, general assignment, and location of each piece of CESE (fig. 6-12).

A responsibility of the dispatcher is to know the current status and location of every assigned piece of equipment. This is accomplished by maintaining the status board and by making, at the end of each work day, a comparison check between the dispatch Equipment Status Board and the Equipment Status Board of cost control.

USN Numbers.— All Navy automotive vehicles, construction equipment, and weight-handling equipment are assigned USN registration numbers for identification. The number assigned to each unit of equipment is keyed to classify the unit by the pertinent subcategory within one of eight major categories of equipment; for example, registration series USN 40-00000 is a major category consisting of earthmoving equipment. 45-00000 of that registration series pinpoints it as a loader. Figure 6-13 shows some of the registration sereis and equipment categories used in the Naval Construction Force.

Equipment Codes.— The equipment codes on the Equipment Status Board are used to establish permanent and positive identification of each piece of equipment; for example, the equipment codes for dozers under the same 48-00000 USN number series identify specific pieces by manufacturer, model, attachments (i.e., winch, ripper, and cab), and so forth.

DISPATCHER'S LOG.— The dispatcher records all vehicles and equipment that are dispatched on the Dispatcher's Log, NAVFAC 9-11240/2 (fig. 6-14). This log sheet, when filled in properly, provides a ready reference as to the location of all the vehicles and equipment dispatched.

*	Code	USN	Description	Location	PM Group	Remarks
(1)	030700	94-88650	Trk 1 4T Util	A CO CDR	37	
(1)	036000	95-19190	Trk 1-1/4T Cargo	Pool	1	
(2)		95-21098		Ops Supervisor	21	Shop 2.20 Deadlined 2.24
(1)	053900	95-16749	Trk 2-1/2T Cargo		2	
(3)	058700	96-27071	Trk 5T Dump	UT Project	3	Excess Ltr 4570 Ser XXX
(3)		96-27072		Pool	23	Excess Ltr 4570 Ser XXX
(4)		96-33439				Due 3.3 Ltr 4610 Ser XXX
(4)		96-33451				Due 3.3 Ltr 4610 Ser XXX
(1)	058800	96-32607	Trk 5T Cargo	UT Project	7	
(1)	060700	96-32926	Trk 5T TT	Pool	5	
(1)	073000	96-36101	Trk Wrecker	Heavy Shop	11	

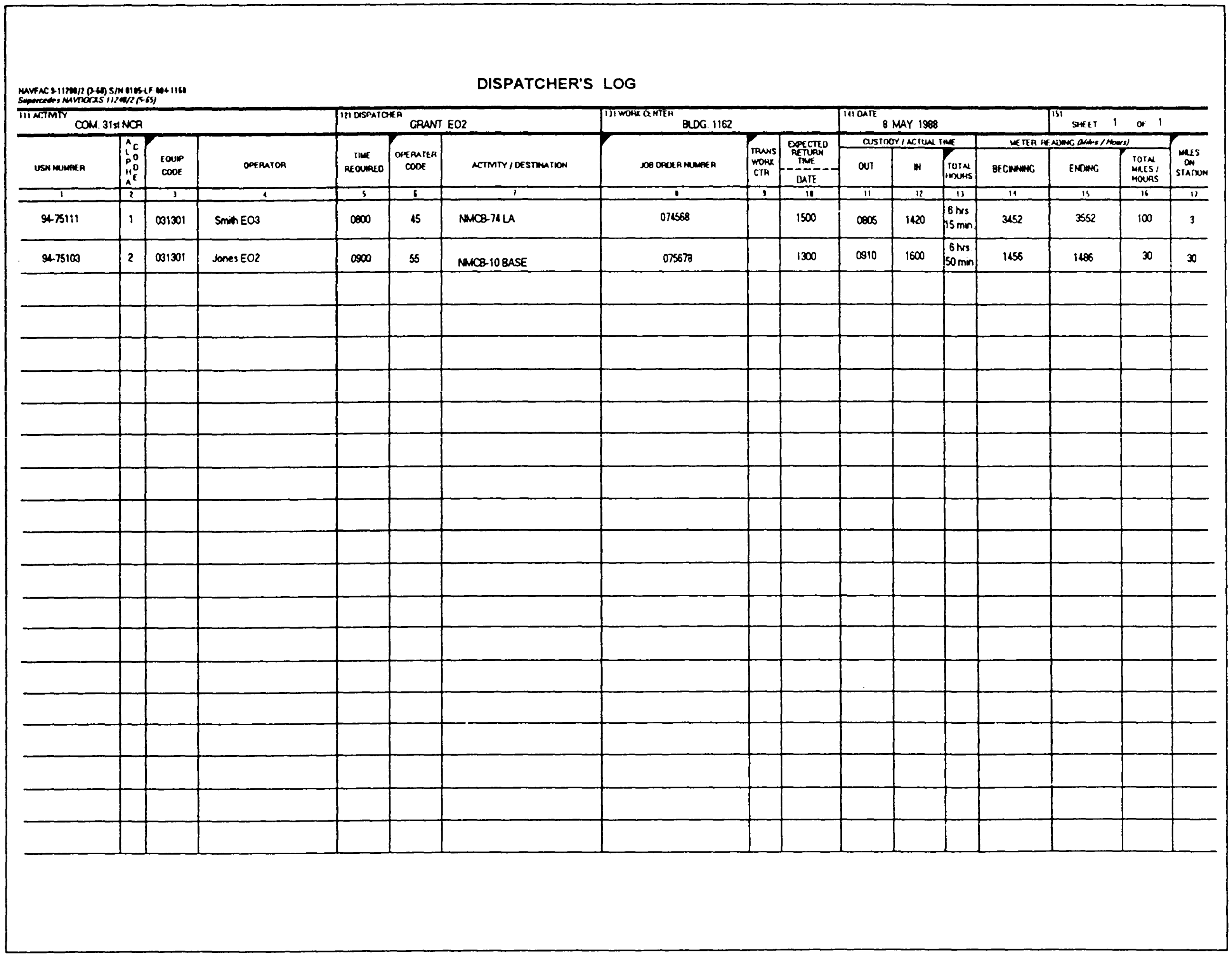
* Optional column for color disc usage

Legend
(1) Black — In-service, Operational
(2) Red — Deadline
(3) Green — Pending Replacement
(4) Orange — Ordered in
(5) Blue — Optional Detachment, Etc.

Figure 6-12.—Equipment Status Board.

Registration Series	Category
USN 20-00000	Crushing, Mixing, Batching and Paving Equipment
21-00000	Batchers
22-00000	Crushing, Washing, and Screening Equipment
23-00000	Finishers
24-00000	Mixers
25-00000	Distributors and Placers
26-00000	Spreaders and Transporters
27-00000	Asphalt Equipment (Miscellaneous)
28-00000	Concrete Equipment (Miscellaneous)
USN 30-00000	Drilling, Blasting, and Driving Equipment
31-00000	Compressors, Air, Portable (60 through 600 cu. ft./min.)
35-00000	Rock Drilling Equipment
36-00000	Pile Drivers
37-00000	Well Drilling and Earth Boring Equipment
USN 40-00000	Earth Moving Equipment
42-00000	Crane, Crawler, Revolving, w/Backhoe, Dragline, Shovel, and Skimmer Attachments
43-00000	Ditchers, Rooters, and Mucking Machines
44-00000	Graders
45-00000	Loaders
46-00000	Rollers
47-00000	Earth and Rock Moving Equipment, Off Highway Trucks, Trailers, and Scrapers
48-00000	Tractors
USN 50-00000	Power Generation and Miscellaneous Construction and Maintenance Equipment
51-00000	Generators (5 KW and up); Welders, Electric Arc; Lighting Equipment, Trailer Mounted
52-00000	Pump, Water, Centrifugal or Diaphragm, Portable, 4-inch to 12-inch capacity, Gas or Diesel
53-00000	Pump, Special Construction and Asphalt, Portable
54-00000	Servicing Equipment (Miscellaneous)
55-00000	Portable Power Operated Pipe Tongs, Amphibious Fueling Hose Reel, and Skid Mounted Air-Conditioning Unit
56-00000	Soil Stabilizing and Lawn Equipment
57-00000	Sweepers, Snowplows, Snowplow Attachments, and Sanders
58-00000	Trash and Garbage Collectors
59-00000	Mobile Machine Shops
USN 60-00000	Railway Equipment (Except Locomotive Cranes)
61-00000	Car, Railway, Cargo Hauling
62-00000	Car, Railway, Self-propelled
63-00000	Car, Railway, Special Purpose
64-00000	Car, Railway, Tank
65-00000	Locomotive, Railway
66-00000	Equipment, Railway, Track Maintenance
67-00000	Car, Railway, Power Generating
68-00000	Station, Railway, Mobile Power
USN 70-00000	Fire Fighting Equipment
71-00000	Fire Truck, Crash and Rescue (CFR)
72-00000	Fire Pump, Portable
73-00000	Fire Truck, Pumper Combination, Structural
74-00000	Fire Truck, Aerial Ladder
75-00000	Generator Foam, Trailer Mounted
USN 80-00000	Weight Handling Equipment
81-00000	Crane, Tractor Mounted or Operated, and Landing Craft, Wheel Mounted
82-00000	Crane, Truck, and Missile-Handling
83-00000	Crane, Floating, and Pile Driver, Floating
84-00000	Crane, Railway, Locomotive
87-00000	Hoist and Winch Power
88-00000	Propelling or Propulsion Unit, Marine Type
89-00000	Pollution Abatement Equipment
USN 90-00000	Passenger Vehicles, Trucks, and Trailers
91-00000	Bus
92-00000	Sedan
93-00000	Station Wagon/Carryall Truck
94-00000	Truck, Light (up to 10,000 LB. GVW;
95-00000	Truck, Medium (10,001 up to 23,999 LB. GVW)
96-00000	Truck, Heavy (24,000 LB. GVW and up)
97-00000	Trailer
98-00000	Motorcycle and Scooter
USN 400000	Vehicles assigned to nonappropriated fund activities
USN 500000	Automotive vehicles leased for a period of 90 days or more
USN 10-00000	Material-handling equipment

Figure 6-13.-Registration Series and Equipment Category.



NAVFAC 9-11240/2 (3-68) S/N 0105-LF-004-1160
Supercedes NAVDOCKS 11240/2 (5-65)

DISPATCHER'S LOG

(1) ACTIVITY COM. 31st NCR
(2) DISPATCHER GRANT EO2
(3) WORK CENTER BLDG. 1162
(4) DATE 8 MAY 1988
(5) SHEET 1 OF 1

USN NUMBER	ALPHA CODE	EQUIP CODE	OPERATOR	TIME REQUIRED	OPERATER CODE	ACTIVITY / DESTINATION	JOB ORDER NUMBER	TRANS WORK CTR	EXPECTED RETURN TIME DATE	CUSTODY / ACTUAL TIME			METER READING (Miles / Hours)			MILES ON STATION
										OUT	IN	TOTAL HOURS	BEGINNING	ENDING	TOTAL MILES / HOURS	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
94-75111	1	031301	Smith EO3	0800	45	NMCB-74 LA	074568		1500	0805	1420	6 hrs 15 min.	3452	3552	100	3
94-75103	2	031301	Jones EO2	0900	55	NMCB-10 BASE	075678		1300	0910	1600	6 hrs 50 min	1456	1486	30	30

Figure 6-14.-Dispatcher's Log, NAVFAC 9-11240/2.

The dispatcher normally maintains a Heavy Equipment Dispatcher's Log, a class C assigned Dispatcher's Log, and a class B assigned Dispatcher's Log. The heavy equipment log is used for dispatching construction and weight-handling equipment, the class C log is used for dispatching automotive and material-handling equipment, and the class B assigned log is used to record dispatched class B assigned vehicles.

Vehicles assignments are divided into three dispatch categories: class A, class B, and class C.

The class A dispatch category is the full-time assignment of a vehicle to an individual that is only authorized by the Chief of Naval Operations (CNO).

The class B dispatch category in the NCF is the once a week assignment of a vehicle that requires a DD Form 1970. The class B assignment in an NMCB is recommended by the equipment officer and approved by the commanding officer.

The class C dispatch category covers all equipment not under class A or class B. Class C assignments are made on an "as-needed" basis. However, members and project crews are normally assigned the same vehicle each day.

The heavy equipment and class C logs are closed out daily, and the class B assigned log, in an NMCB, is closed out weekly. Closing out a log is done by adding all the ending mileage and hour meter readings and enclosing the reports and records inside the appropriate folded Dispatcher's Log. On the outside of the log, the dispatcher records the date, total mileage, and total operating hours of all the equipment dispatched.

On the first work day of each week, the transportation supervisor collects the Dispatcher's Logs for the Alfa company operations supervisor so they can be reviewed as required by the COMSECOND/ COMTHIRDNCBINST 11200.1 Series.

In the NCF, the logs are retained on file by the dispatcher for a period of 90 days. At a public works, the DD Form 1970 is retained for 90 days and the Dispatcher's Logs are retained for 36 months.

TROUBLE REPORTS FILE.— The Trouble Reports Fide, commonly known as the **Hard-Card File,** is used to hold the NAVFAC 9-11240/13 (Hard Card) and the NAVFAC 11260/4 (Operator's Daily PM Report) that have documented repairs above the operator's area of responsibility not requiring immediate attention and are not a safety-related item.

To avoid disrupting the PM-to-interim repair ratio, you should store these cards with documented repairs in the Trouble Reports File until the piece of equipment is scheduled for a preventive maintenance (PM) inspection. The PM-to-interim repair ratio is the number of scheduled preventive maintenance actions compared to unscheduled maintenance actions (interim repairs). The normal goal is three scheduled PM inspections to each interim repairs. The standard interval between PM service inspections for NCF equipment is 40 working days; therefore, the Trouble Reports File is divided into 40 PM group sections, covering each of these working days.

When apiece of equipment is scheduled for PM, the cards in the Trouble Reports File for that USN are forwarded with the piece of equipment.

YARD BOSS

The yard boss and the dispatcher work as a team. The yard boss has a key part in the Equipment Management Program by enforcing and providing technical guidance for operator pre- and post-operational checks and maintenance procedures that reduce equipment breakdown. Additionally, the yard boss manages the equipment yard and the vehicles parked in it, establishes and enforces traffic control through the yard, such as stop signs, speed limits, and one-way-traffic flow, and is in charge of yard maintenance and the establishment of parking lines and areas, such as a ready line and awaiting-entry-into-shop line. The yard boss sees and hears the equipment that dispatchers cannot see while sitting behind their desks.

The yard boss is also responsible for cycling equipment in the pool that is not regularly used. Equipment must be maintained in a standby status and cycled on a weekly basis at its rated capacity for its intended use. Cycling exercises and protects equipment from deterioration. Equipment cycling must be documented in a cycle log maintained by the yard boss, documenting the date, USN number, duration of cycle, and deficiencies.

Tool Kit

To provide tools for operator maintenance procedures, the yard boss has a tool kit in the Battalion Table of Allowance for the support of the Yard Boss Program. The Kit 80111 provides the minimum tools and equipment resources necessary to support operator maintenance. For control and accountability of the tools, the yard boss should have operators sign a log book for the tools checked out. The yard boss must also provide grease guns, valve caps, and light bulbs.

Washrack

As a member of the transportation pool, you maybe assigned as a washrack attendant to assist the yard boss in maintaining washrack operations. The washrack supports the Equipment Management Program by providing means for the daily cleaning of equipment that allows the detection and prevention of major problems.

Thorough cleaning of equipment cannot be accomplished with water alone. A supply of soap, brushes, buckets, serviceable hoses, and a trash can enhance the operation of the washrack.

Preventive Maintenance

The yard boss and the dispatcher must work as a team in order to ensure that equipment due for PM is available and is prepared to be turned in the morning of the scheduled PM due date. This team approach allows the mechanic shop to process and service the equipment on schedule.

When a piece of equipment is due for PM, the yard boss receives a NAVFAC 9-11240/13 (Hard Card) from the dispatcher. The dispatcher has the responsibility of maintaining a Hard Card log book and issuing a Hard Card number for tracking the maintenance of the equipment. The yard boss has the responsibility for ensuring the equipment and attachments are cleaned, lubricated, and processed through collateral equipage.

A recommended flow for PM Hard Cards is to have the yard boss submit two Hard Cards stamped “PM” and initialed by the collateral equipage custodian. The equipment, Hard Card, and cards from the Trouble Reports File for the USN are sent to the mechanic equipment inspector. The mechanic equipment inspector has the responsibility to accept or reject the equipment, depending on cleanliness and lubrication. For equipment that is accepted the yard boss has the mechanic inspector sign receipt of the Hard Cards and retains one for the dispatch records.

Saltwater Operations

Operating on beaches, loading and unloading landing craft units, and participating in amphibious operations often expose CESE to salt water and wet sand. Every effort must be made to minimize equipment operations near salt water. Exposure to saltwater causes premature damage to brake systems, lubrication fluids, bearings, extensive rust, and overall equipment failure.

PREINSPECTION.— Before beach operations, equipment must be thoroughly inspected and prepared. The equipment must be in good operating condition, so the possibility of failure in the water is reduced. The fan disconnect must work and all fording equipment must be watertight and connected correctly. If the equipment does not have a fan disconnect and has to perform operations in the water, loosen or remove the fan belt. If you are unsure, consult the maintenance supervisor for clear directions. Use of water-resistant greases, antiseize, antirust compounds, and application of a light oil spray on the undercarriages will reduce corrosion.

OPERATING PRECAUTIONS.— When equipment must enter the water, enter as slowly as possible to reduce the possibility of radiator damage. When swell and surf actions are present, ensure that the equipment does not become submerged below its high water mark. Take caution when operating at low tides because of the incoming tide.

AFTER OPERATIONS SERVICE.— Immediately after operating CESE in or around salt water, you should clean and wash it thoroughly with fresh water. Ensure that all areas are washed and all accumulations of wet sand are removed. A thorough PM inspection should be performed by the mechanic shop, giving special attention to possible contamination of the gearbox and fluid reservoir lubricants. If salt water is detected, the reservoir and the system must be emptied, flushed, and refilled. A light oil spray on the undercarriages after washing down with fresh water can be used to reduce corrosion.

RECOVERY PROCEDURES.— Immediately after recovering equipment that has been submerged, the following procedures must be taken:

1. Wash and clean the equipment thoroughly with fresh water. Ensure that all the areas are washed and all the sand and the mud are removed.

2. Wash and flush out the engine with an oil and diesel fuel mixture. Remove the spark plugs or fuel injectors and turn the engine over.

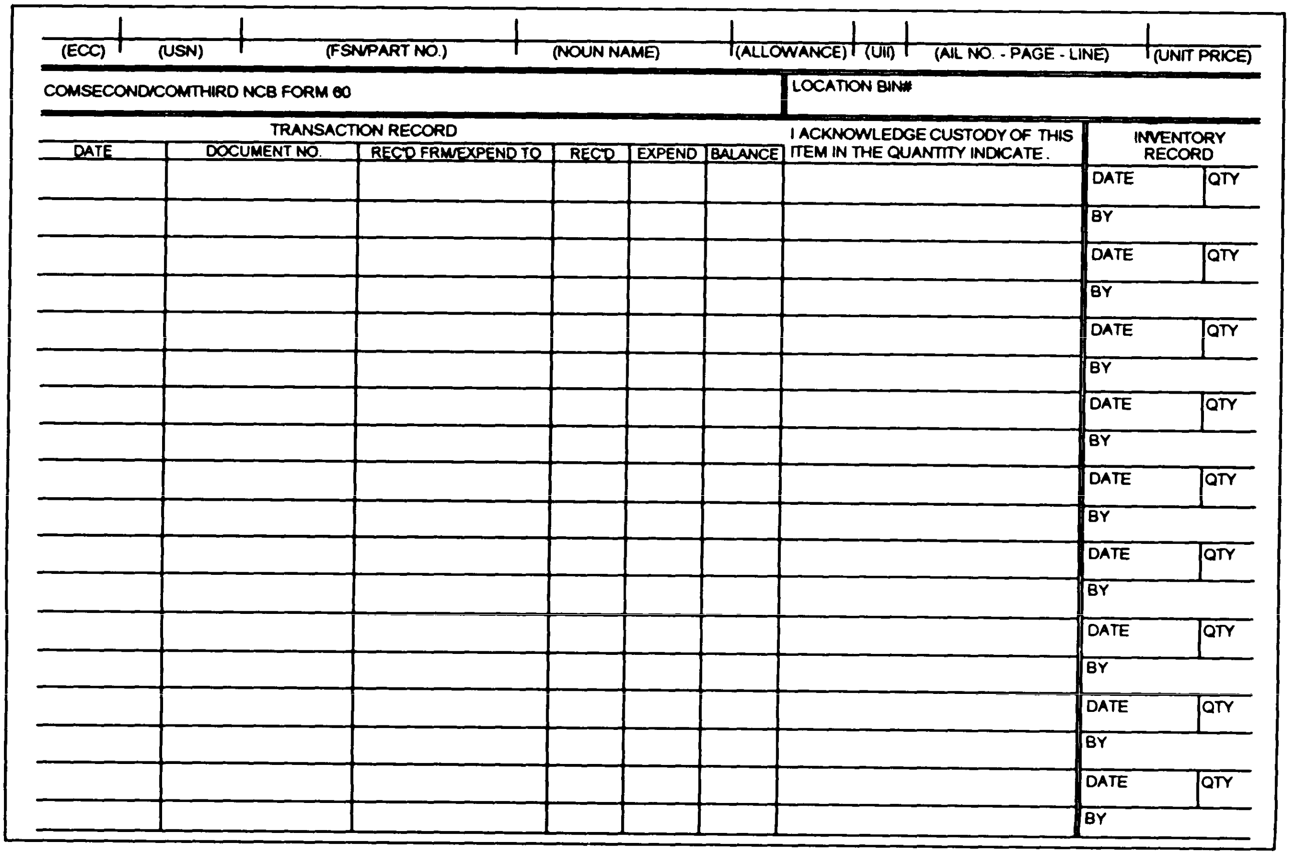
3. Wash and flush out all the fluid reservoirs and compartments and replace all the falters.

4. It is extremely important to get the engine running as quickly as possible. If the engine will not start, it must be disassembled as quickly as possible, cleaned, and reassembled.

NOTE: A common practice in the NCF is that the equipment operator who submerges or buries a piece of equipment supports the recovery, cleaning, and maintenance service of the equipment.

COLLATERAL EQUIPAGE CUSTODIAN

As a member of the transportation pool, you may be assigned as the collateral equipage custodian. Two



(ECC) (USN) (FSN/PART NO.) (NOUN NAME) (ALLOWANCE) (UII) (AIL NO. - PAGE - LINE) (UNIT PRICE)

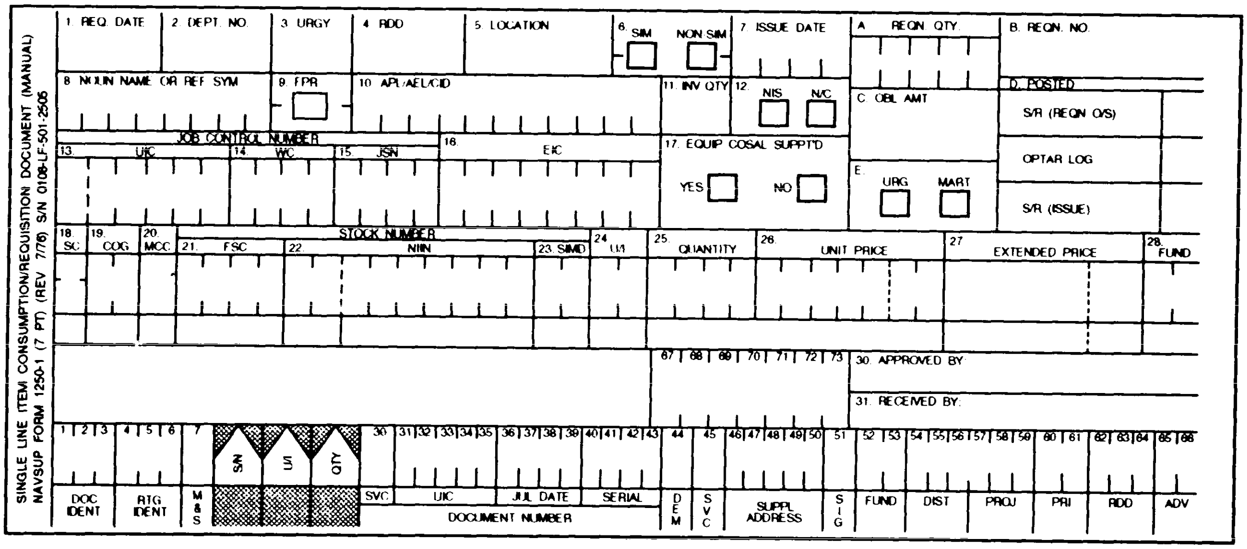
COMSECOND/COMTHIRD NCB FORM 60

LOCATION BIN#

TRANSACTION RECORD

DATE	DOCUMENT NO.	REC'D FRM/EXPEND TO	REC'D	EXPEND	BALANCE	I ACKNOWLEDGE CUSTODY OF THIS ITEM IN THE QUANTITY INDICATE.	INVENTORY RECORD	
							DATE	QTY
							BY	
							DATE	QTY
							BY	
							DATE	QTY
							BY	
							DATE	QTY
							BY	
							DATE	QTY
							BY	
							DATE	QTY
							BY	
							DATE	QTY
							BY	
							DATE	QTY
							BY	
							DATE	QTY
							BY	

Figure 6-15.-Collateral Custody Record Card, COMSECOND/COMTHIRDNCB 60 Form.



SINGLE LINE ITEM CONSUMPTION/REQUISITION DOCUMENT (MANUAL)
NAVSUP FORM 1250-1 (7 PT) (REV 7/76) S/N 0108-LF-501-2505

1. REQ. DATE
2. DEPT. NO.
3. URGY
4. RDD
5. LOCATION
6. SIM ☐ NON-SIM ☐
7. ISSUE DATE
A. REQN. QTY.
B. REQN. NO.
8. NOUN NAME OR REF SYM
9. FPR ☐
10. APL/AEL/CID
11. INV QTY
12. NIS ☐ N/C ☐
C. OBL. AMT
D. POSTED
S/R (REQN O/S)
OPTAR LOG
S/R (ISSUE)
JOB CONTROL NUMBER
13. UIC
14. WC
15. JSN
16. EIC
17. EQUIP COSAL SUPPT'D YES ☐ NO ☐
E. URG ☐ MART ☐
STOCK NUMBER
18. SC
19. COG
20. MCC
21. FSC
22. NIIN
23. SMD
24. UI
25. QUANTITY
26. UNIT PRICE
27. EXTENDED PRICE
28. FUND
67 68 69 70 71 72 73
30. APPROVED BY:
31. RECEIVED BY:
1 2 3 4 5 6 7 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66
S/N UI QTY
DOC IDENT
RTG IDENT
M & S
SVC
UIC
JUL DATE
SERIAL
DOCUMENT NUMBER
DEM
SVC
SUPPL ADDRESS
SIG
FUND
DIST
PROJ
PRI
RDD
ADV

Figure 6-16.-Single-Line Item Consumption/Management Document (Manual), NAVSUP Form 1250-1.

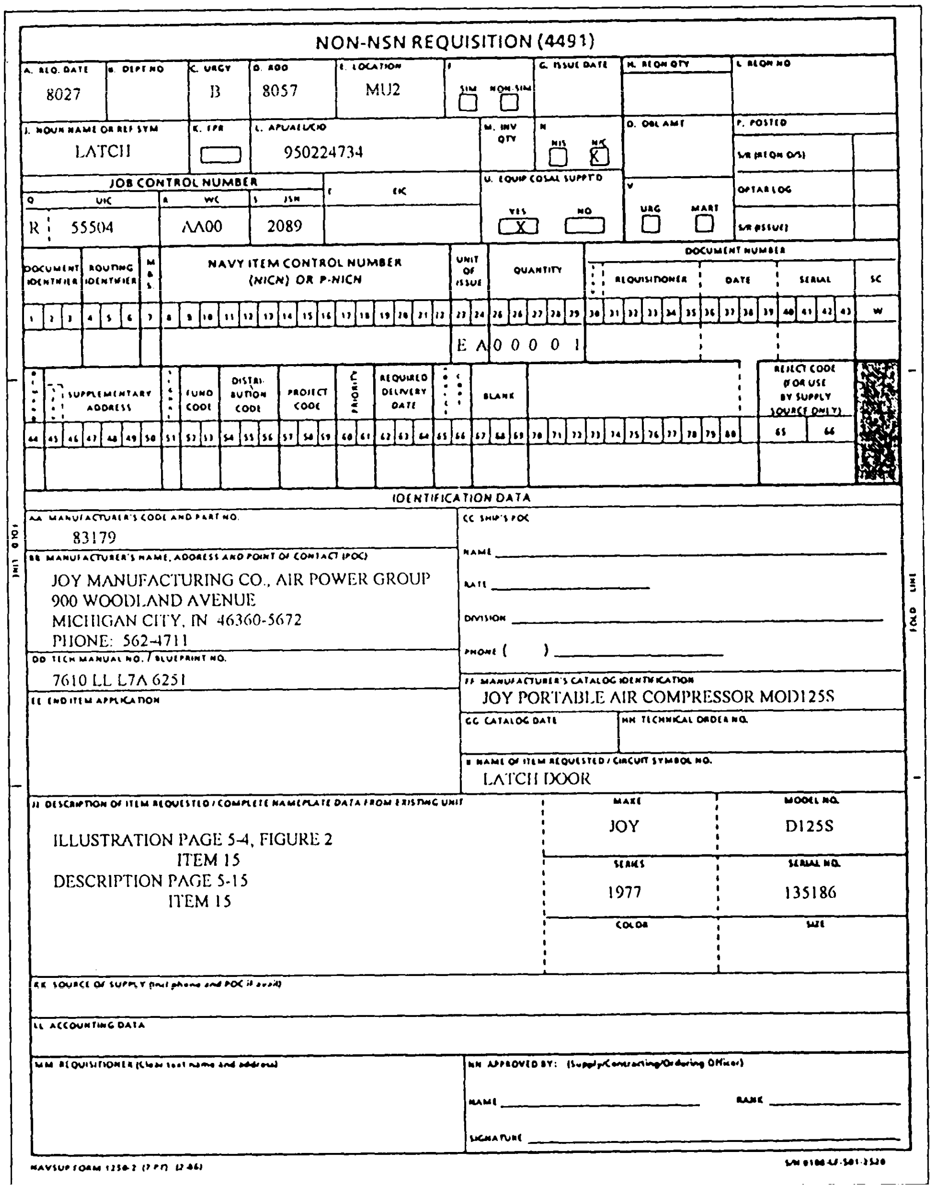
basic types of collateral equipage are **component collateral equipage** and **tactical collateral equipage.**

COMPONENT collateral equipage consists of items, such as hoses for pumps and bits for the earth auger. These items are normally procured on the same contract as the basic machine. The history jacket should contain a list of the amount and types of component collateral equipage.

TACTICAL collateral equipage consists of items common to the equipment, such as top canvas and tarpaulin, bows and side racks, spare tire and rim, jack and lug wrench, and chains with hooks and binders.

The collateral equipage custodian maintains a Collateral Custody Record Card, COMSECOND/COMTHIRDNCB 60 Form (fig. 6-15), for each line item of equipage for each unit of equipment. The equipage custodian enters all outstanding requisitions, receipts, issues, location, losses, and annotates the allowance of a particular line item of equipage for each CESE on the CB 60 form.

The equipage custodian maintains the CB 60 forms in folders for each USN-numbered unit of CESE. The CB 60 forms are pulled on the PM date to perform an inventory of mounted or stored collateral equipage for each unit of CESE entering the shop. The equipage custodian prepares a NAVSUP Form 1250-1 (fig. 6-16) or a 1250-2 (fig. 6-17) for lost, damaged or deteriorated collateral equipment. Outstanding requisitions, amount of gear on hand, and the date inventoried are all


NON-NSN REQUISITION (4491)

A. REQ. DATE	B. DEPT NO	C. URGY	D. RDD	E. LOCATION	F	G. ISSUE DATE	H. REQN QTY	I. REQN NO
8027		B	8057	MU2	SIM ☐ NON-SIM ☐			

J. NOUN NAME OR REF SYM	K. FPR	L. APUA/UCIO	M. INV QTY	N	O. OBL AMT	P. POSTED
LATCH	☐	950224734		NIS ☐ NC ☒		S/R (REQN O/S)

JOB CONTROL NUMBER

Q	UIC	R WC	S JSN	T EIC	U. EQUIP COSAL SUPP'TD	V	
R	55504	AA00	2089		YES ☒ NO ☐	URG ☐ MART ☐	OPTAR LOG S/R (ISSUE)

DOCUMENT IDENTIFIER	ROUTING IDENTIFIER	M & S	NAVY ITEM CONTROL NUMBER (NICN) OR P-NICN	UNIT OF ISSUE	QUANTITY	DOCUMENT NUMBER: REQUISITIONER	DATE	SERIAL	SC
1 2 3	4 5 6	7	8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	23 24	25 26 27 28 29	30 31 32 33 34 35	36 37 38 39	40 41 42 43	W
				EA	00001				

SUPPLEMENTARY ADDRESS		FUND CODE	DISTRIBUTION CODE	PROJECT CODE	PRIORITY	REQUIRED DELIVERY DATE		BLANK		REJECT CODE (FOR USE BY SUPPLY SOURCE ONLY)	
44	45 46 47 48 49 50	51	52 53	54 55 56	57 58 59	60 61	62 63 64	65 66	67 68 69 70 71 72 73 74 75 76 77 78 79 80	65	66

IDENTIFICATION DATA

AA. MANUFACTURER'S CODE AND PART NO.
83179

BB. MANUFACTURER'S NAME, ADDRESS AND POINT OF CONTACT (POC)
JOY MANUFACTURING CO., AIR POWER GROUP
900 WOODLAND AVENUE
MICHIGAN CITY, IN 46360-5672
PHONE: 562-4711

CC. SHIP'S POC
NAME ______
RATE ______
DIVISION ______
PHONE ( ) ______

DD. TECH MANUAL NO./BLUEPRINT NO.
7610 LL L7A 6251

EE. END ITEM APPLICATION

FF. MANUFACTURER'S CATALOG IDENTIFICATION
JOY PORTABLE AIR COMPRESSOR MOD125S

GG. CATALOG DATE

HH. TECHNICAL ORDER NO.

II. NAME OF ITEM REQUESTED/CIRCUIT SYMBOL NO.
LATCH DOOR

JJ. DESCRIPTION OF ITEM REQUESTED/COMPLETE NAMEPLATE DATA FROM EXISTING UNIT
ILLUSTRATION PAGE 5-4, FIGURE 2
ITEM 15
DESCRIPTION PAGE 5-15
ITEM 15

MAKE	MODEL NO.
JOY	D125S
SERIES	**SERIAL NO.**
1977	135186
COLOR	**SIZE**

KK. SOURCE OF SUPPLY (incl phone and POC if avail)

LL. ACCOUNTING DATA

MM. REQUISITIONER (Clear text name and address)

NN. APPROVED BY: (Supply/Contracting/Ordering Officer)
NAME ______ RANK ______
SIGNATURE ______

NAVSUP FORM 1250-2 (7 PT) (2-86)
S/N 0108-LF-501-2520

Figure 6-17.—Non-NSN Requisition, NAVSUP Form 1250-2.

documented on the CB 60 form. The NAVSUP Form 1250s are reviewed and approved by the maintenance supervisor.

NOTE: The inventory procedures are accountable man-hours on the Equipment Repair Order.

The operators of class B assigned CESE sign the CB 60 form assuming full custody of mounted collateral gear. CB 60 forms for class C mounted collateral gear on CESE are signed by the yard boss. The mounted collateral gear is annotated on the daily trip ticket, and custody is assumed by the operator who signs the trip ticket, or the collateral equipage can be issued and returned to collateral each time the unit of CESE is dispatched.

ATTACHMENT CUSTODIAN

The attachment custodian maintains a card file and log that shows an accurate inventory of receipts and issues of attachments, when the attachments were last lubricated, and any damage incurred from one operation to another. In addition, the custodian is responsible for the segregated storage of all attachments and their associated accessories.

Attachments are accessories to construction equipment that enable the basic equipment to perform its function or add versatility. Attachments are stored on hardstands to keep the items out of sand, mud, and water. Hydraulic lines and fittings are sealed for protection from dirt and moisture.

Attachment accessories, such as bucket teeth, sprockets, drum lagging, and wedges, are placed in boxes or on pallets and marked for the appropriate equipment. Wire rope, sheaves, and bolt threads are lubricated. Nuts and bolts are stored in their respective holes on the attachments when possible. Exposed machined surfaces and open parts are preserved to prevent oxidation and damage. Storage is maintained so all attachments belonging to one USN number are stored together.

The attachment custodian is responsible for the Attachments Status Board (fig. 6-18), maintained in the dispatcher's office. The Attachments Status Board reflects the attachment code, NAVFAC identification number, abbreviated description, the USN number of the equipment to which the attachment is assigned the PM group (same as the equipment the attachment is assigned), the location of the attachment, and remarks. The collateral equipage custodian normally performs the duties of the attachment custodian.

FUEL TRUCK DRIVER

Fuel operations in an NMCB are managed by the transportation pool supervisor. The management of fuel operations is normally delegated to the fuel truck driver who must be mature, independent, and reliable.

NOTE: A poorly managed fuel program results in needless downtime of equipment and delays in production.

The fuel truck driver must possess the knowledge, skill, and abilities to accomplish the following:

1. Use the Equipment Status Board to determine the location of all CESE.

2. Know the fuel requirements and function of equipment used on construction sites.

ATTACHMENTS STATUS BOARD

Code	NAVFAC I.D. NO.	Description	USN No. Assigned	PMG	Location and Remarks
A01000	L175B-BH-5	Backhoe	45-01799	17	Attachment Pad
A02500	255-BB-56	Boom Butt	42-01778	9	42-01778
A03000	32-BE-72	Boom Ext	82-03173	14	Attachment Pad

Figure 6-18.-Attachments Status Board.

3. Avoid fueling equipment with the wrong fuel or filling hydraulic systems or cooling systems with the fuel.

4. Maintain accurate records in a log documenting amounts of fuel issued, by equipment USN number.

5. Ensure fuel availability for contingency readiness, daily transportation, and construction operations.

6. Maintain fire extinguishers on the tanker truck as set forth in the U.S. Army Corps of Engineers, *Safety and Health Requirements Manual,* EM 385-1-1.

7. Be alert to avoid environmental pollution. Fuel spillage can be disastrous.

8. Daily communicate with the yard boss, dispatcher, and the transportation supervisor.

9. Be a qualified professional operator of the fuel truck.

Fuel-Handling Vehicle

Fuel-handling vehicles are classified as fuel tank trucks or fuel tank semitrailers. Each vehicle has distinguishing characteristics (model, size, and capacity). The purpose of fuel-handling vehicles is to load, haul, and discharge fuel to other vehicles, aircraft, or fuel depots.

DESCRIPTION.— A typical fuel tank truck is equipped with a tank body divided into compartments. Each compartment has a manhole and filler cover assembly, bottom sump or well, and discharge valves with screen assemblies and drainpipes. The drainpipes end in a manifold in the equipment Compartment. The compartment (fig. 6-19) also houses a delivery pump, a discharge valve control assembly, a pump delivery line gate valve, an automatic dump valve, drain tube valves, a gravity line gate valve, a filter separator, a pressure gate, a meter, a water separator chamber, and a grounding cable.

The delivery pump is powered by the power takeoff (PTO), which is controlled by the PTO lever located in the cab of the truck. The lever is moved backward to the ENGAGED position to engage the PTO which causes the pump to operate. The lever is moved forward to the DISENGAGED position to disengage the PTO and to stop the pump.

The discharge valve control assembly levers control the discharge valves located at the bottom of each tank

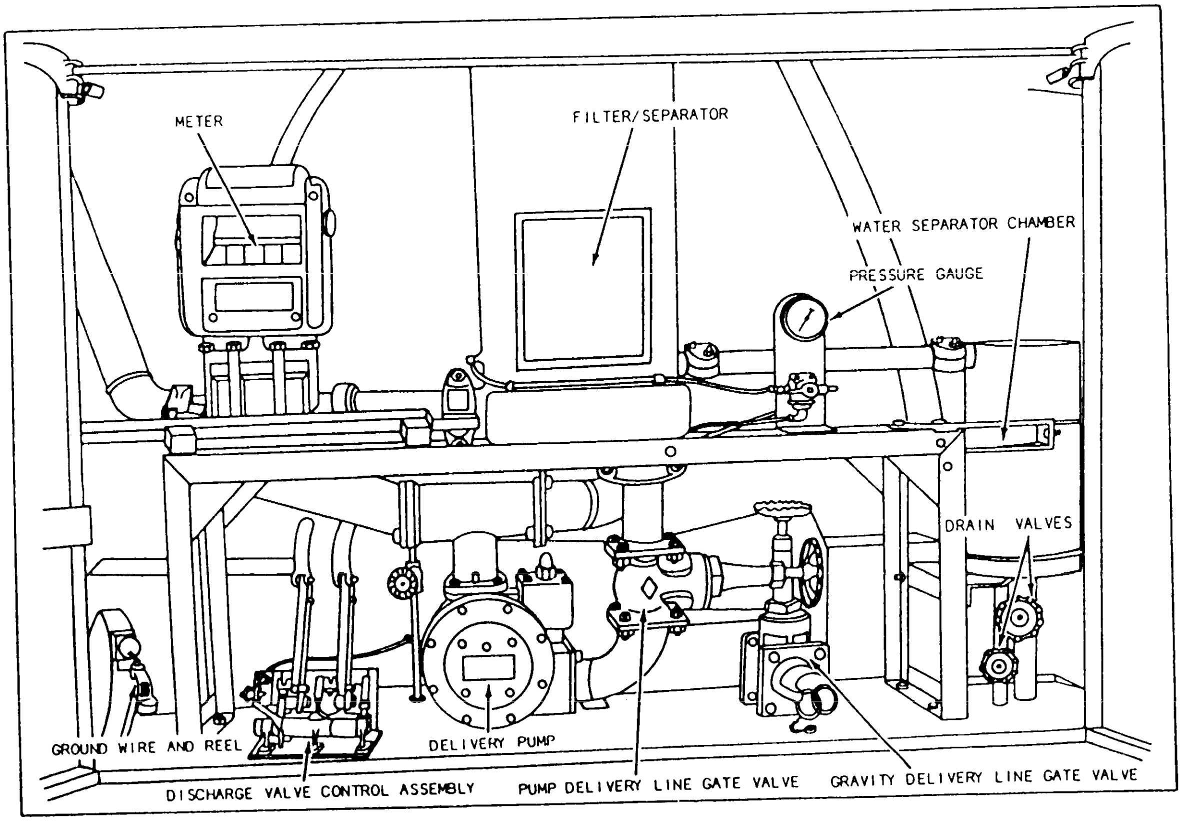


Figure 6-19.-Dispensing equipment compartment.

compartment. Pulling back on a lever opens a discharge valve and permits the flow of fuel into the piping system. Squeezing the trip rod operation handle mounted on the lever and moving the lever forward locks the compartment valve and shuts off the flow of fuel.

In an emergency, the discharge valve remote control lever, located on the left side of the discharge valve control operating lever bank, provides a means of locking all discharge valves. Pulling the handle causes a release lever to trip the operating levers and locks the valves.

OPERATION.— When operating the fuel tank truck for discharging fuels, follow instructions prescribed in the manufacturer's operating manual. The general instructions which follow are typical of the type of fuel tank truck used in the NCF.

Tank trucks are used to haul and dispense fuels. (See fig. 6-20.) The tank truck shown is equipped with a stainless steel, 1,200-gallon tank body, which is divided into two 600-gallon compartments (fig. 6-21). The fuel delivery system is equipped with an upright filter/separator and meter. Since there are only two tank compartments, the discharge valve control has two operating levers, as shown in figure 6-21. There is a speed control linkage assembly that controls the speed of the engine, power takeoff, and delivery pump.

The filter/separator in figure 6-21 is equipped with three filter elements, three go no-go fuses, a pressure gauge, and an automatic dump (drain) valve. The primary function of the filter element is to collect solid contaminants and separate water from the fuel.

The go no-go fuses shut off the fuel flow if water or solid contaminants exceed a safe level; the shutoff of fuel flow indicates the falters are not operating properly. If such a malfunction exists, it must be located and corrected and the fuses replaced before operation is continued.

The automatic dump (drain) valve is float-operated. The float sinks in fuel but rises in water. When water is present in the valve housing, the float rises, the valve opens, and the water drains away through the valve drain tube. Open the automatic dump (drain) valve during fueling operations. Check the pressure differential every day that equipment is in use and while the pump is operating.

Close the meter drain valve, delivery pump drain cock, and filter/separator drain valve. Open the automatic dump (drain) valve. Enter the driver 's compartment and start the engine; depress the clutch, and put the transfer case shift lever in NEUTRAL; place the PTO lever in the ENGAGED position; then place the transmission gearshift lever in the gear position recommended by the manufacturer, and release the clutch.

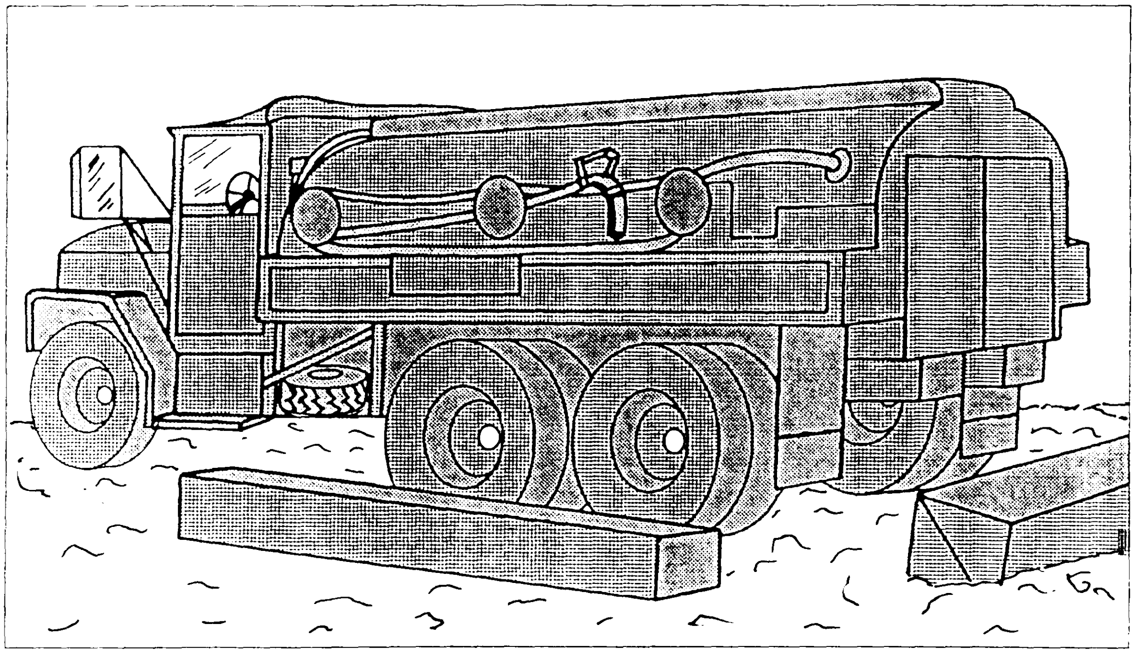


Figure 6-20.-Fuel-service truck.

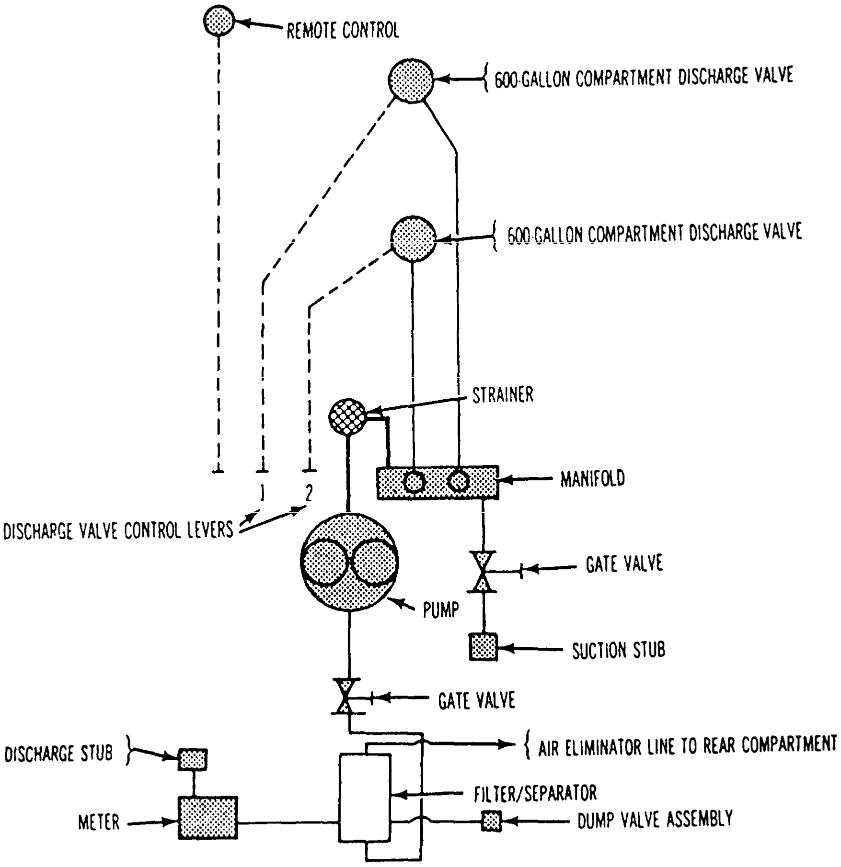

REMOTE CONTROL
600-GALLON COMPARTMENT DISCHARGE VALVE
600-GALLON COMPARTMENT DISCHARGE VALVE
STRAINER
MANIFOLD
1
2
DISCHARGE VALVE CONTROL LEVERS
GATE VALVE
PUMP
SUCTION STUB
GATE VALVE
AIR ELIMINATOR LINE TO REAR COMPARTMENT
DISCHARGE STUB
FILTER/SEPARATOR
METER
DUMP VALVE ASSEMBLY

Figure 6-21.—Fuel-service truck diagram.

CAUTION

> Allowing the engine to run with the transmission engaged and the transfer case shift lever in NEUTRAL without the PTO in the ENGAGE position will cause bearing failure in the transfer case. Be sure to shift the transmission gearshift lever to NEUTRAL when not operating the power takeoff.

After the fuel dispensing pump is engaged set the throttle rpm to the manufacturer's recommended setting. Move the discharge valve control levers to the open position; and be sure, before pumping operations begin, to attach the grounding wire to the vehicle being serviced. Open the pump delivery line hose and squeeze the nozzle operating lever to discharge the fuel.

After discharging the fuel, close the pump delivery line gate valve, and move the discharge valve control operating lever to the CLOSED position.TIhen close the automatic dump valve drain tube valve. Return to the driver's compartment; set the rpms to idle, depress the clutch and place the transmission gearshift lever in NEUTRAL; then place the transfer power takeoff shifting lever to DISENGAGED, and stop the engine.

When changing from one type of fuel to another, drain and flush the fuel compartments, pump filter/separator, service lines, manifold, meter, gauge, and dispensing hoses and nozzles.

NOTE: All pumping mechanisms are not controlled and operated in the same manner. Each make or model operates differently. If you are in doubt as to the proper pump operation and maintenance procedures, study the operator's manual and the caution and instruction plates located near the pump and control mechanisms.

Fuel Safety

Drivers of fuel tank trucks must observe safe driving practices, some of which are listed below.

- Drive defensively and make allowances for other drivers.
- Make turns only from proper lanes, and signal intent to other drivers. Never leave the proper lane

except when necessary and then only when it is safe to do so.

- Avoid excessive speeds at all times. The fuel tank truck is top-heavy when loaded with fuel, and unstable when partially filled with fuel. The operator must be alert when traveling over rough terrain, on gravel, and on curves. Be alert for passing or approaching traffic.
- Drive downgrade in the same gear that would be used to drive upgrade.
- Move completely off the road if possible, when parking. Set the brakes and chock the wheels when parked on a grade. Set flags during the day and set reflectors at night.
- Stop at all railroad crossings, and be especially watchful if there are multiple tracks.
- Keep your vehicle moving to prevent an accumulation of vapor if a small leak develops. Arrange to discharge the load at the nearest point.
- Ask for assistance if a large amount of fuel is escaping which may be the case if the vehicle is damaged. Immediately secure the engine, cordon the area, and obtain fire-fighting and security support.
- Avoid driving past a fire or near the site until it is safe to do so.
- Never smoke on or about tank vehicles used for hauling flammable liquids. Carry no matches on such vehicles.
- Examine tires occasionally on long hauls for air pressure and for damage that could cause an accident.
- Fuel-handling vehicles should be parked in the least congested area of a pool, properly marked with the type of fuel on board, and No Smoking Within 50 Feet signs visible from any direction. Remember: SAFETY FIRST.

BUS DRIVER

A bus driver must be mature and reliable and must ensure a bus is safe before driving it. Besides performing the normal prestart procedures, the following are items the operator must ensure are in good working order:

1. Service brakes
2. Parking brake
3. Steering mechanism
4. Lights and reflectors
5. Tires and horn
6. Windshield wipers
7. Rearview mirror or mirrors
8. Wheels and rims

Additionally, check the interior of the bus to ensure rider safety. Aisles and stairwells must always be clear and the following must be in a safe working condition:

1. Each handhold and railing
2. Floor covering
3. Signal devices (emergency door buzzer)
4. Emergency exit handles
5. Emergency exit sign visible
6. Seats secured to the bus

NOTE: The bus must have a fire extinguisher and emergency reflectors as outlined in the *Federal Motor Carrier Safety Regulations Pocketbook,* ORS-7A. Additionally, the bus must also have spare electrical fuses unless equipped with circuit breakers.

When performing the normal prestart inspection procedures for a bus, you should use the Bus Inspection Memory Aid (fig. 6-22).

The bus driver has the responsibility for the orderly behavior and safety of all passengers and cargo and should be neat in appearance and maintain a courteous attitude.

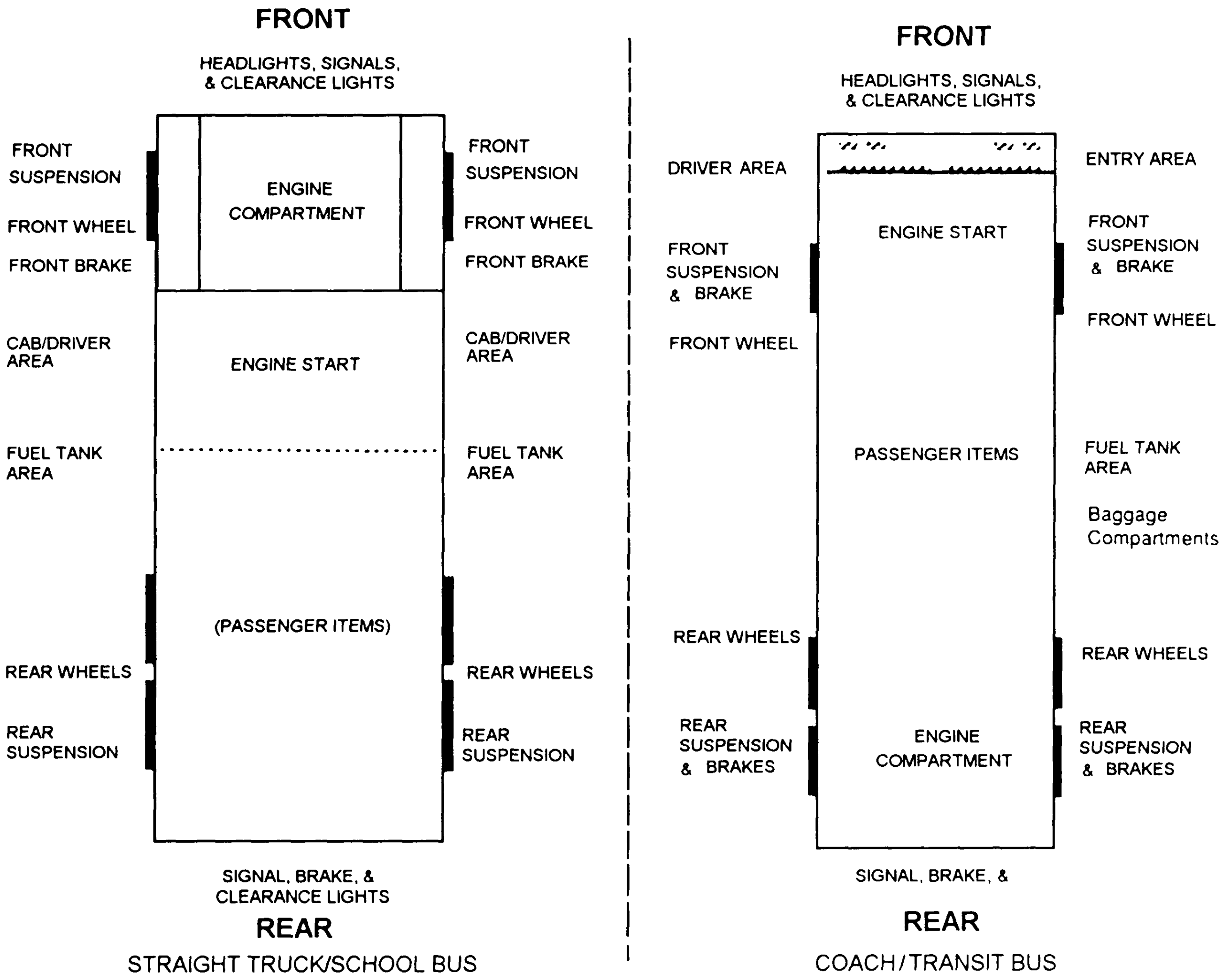
The following are rules a bus driver must follow when operating a bus:

1. Do not allow a rider to stand forward of the rear of the driver's seat. Buses, designed to allow standing, should have a 2-inch line on the floor or some other means showing riders where they cannot stand. This line is called the **standee line,** and all passengers must stay behind it.

2. Do not put a bus in motion with the doors open, and do not close the doors until all passengers are completely clear of the doors.

3. Pay attention to the road when driving and do not carry on unnecessary conversation with the passengers while the vehicle is in motion.

VEHICLE INSPECTION MEMORY AIDS
(KEY LOCATIONS TO INSPECT)


FRONT
HEADLIGHTS, SIGNALS, & CLEARANCE LIGHTS
FRONT SUSPENSION
FRONT WHEEL
FRONT BRAKE
ENGINE COMPARTMENT
FRONT SUSPENSION
FRONT WHEEL
FRONT BRAKE
CAB/DRIVER AREA
ENGINE START
CAB/DRIVER AREA
FUEL TANK AREA
FUEL TANK AREA
(PASSENGER ITEMS)
REAR WHEELS
REAR WHEELS
REAR SUSPENSION
REAR SUSPENSION
SIGNAL, BRAKE, & CLEARANCE LIGHTS
REAR
STRAIGHT TRUCK/SCHOOL BUS
FRONT
HEADLIGHTS, SIGNALS, & CLEARANCE LIGHTS
DRIVER AREA
ENTRY AREA
ENGINE START
FRONT SUSPENSION & BRAKE
FRONT SUSPENSION & BRAKE
FRONT WHEEL
FRONT WHEEL
PASSENGER ITEMS
FUEL TANK AREA
Baggage Compartments
REAR WHEELS
REAR WHEELS
REAR SUSPENSION & BRAKES
ENGINE COMPARTMENT
REAR SUSPENSION & BRAKES
SIGNAL, BRAKE, &
REAR
COACH/TRANSIT BUS

SAFETY NOTE: ALWAYS PUT VEHICLE KEY IN YOUR POCKET--OR SOMEONE MIGHT MOVE THE VEHICLE WHILE YOU ARE CHECKING UNDERNEATH IT.

Figure 6-22.-Bus Inspection Memory Aid.

4. Stop, start, and operate buses smoothly and without jerks or sudden changes in acceleration When making a turn or upon approaching a sharp curve, reduce your speed and use care to avoid injuring passengers.

5. While driving, scan the interior of the bus as well as the road ahead, to the sides, and to the rear. You may have to remind personnel to keep arms and heads inside the bus.

6. Stop your bus between 15 and 50 feet before railroad crossings. Look and listen in both directions for trains. You should open the door if it improves your ability to see or hear an approaching train. Before crossing after a train has passed be sure there is not another train coming in either direction on other tracks. When it is safe to cross, drive the bus completely across the crossing without changing gears. You do not have to stop but must slowdown and carefully check for other vehicles at the following locations:

- At streetcar crossings
- At railroad tracks used only for industrial switching within a business district
- Where a policeman or flagman is directing traffic
- If a traffic signal shows green
- At crossings marked “exempt crossing”

Adhere to the standards and procedures contained in the *Commercial Driver License (CDL) Handbook* for the state or states you operate in.

Transportation of Personnel

In an NMCB, the daily transporting of troops is provided not only through the use of buses but also through the use of cargo trucks equipped with side racks and seats. The driver of a cargo truck is responsible for the safety of all passengers and cargo and should adhere to the same rules as outlined for bus operations.

Additional safety rules used when transporting personnel in cargo trucks areas follows:

1. The number of passengers must not exceed the number that can be seated.

2. Trucks used to transport personnel must be equipped with a seating arrangement securely anchored, have a rear endgate, a guardrail, and a safety strap. Steps or ladders for loading and unloading must be provided and used.

3. All tools and supplies must be stowed and secured when transported with personnel.

4. Passengers must not ride with their arms or legs outside of the truck body, in a standing position on the body, or on running boards, or seated on side finders, cabs, cab shields, or on top of a load.

5. No explosives, flammable materials, or toxic substances may be transported in vehicles carrying passengers.

6. The driver must ensure that all personnel are seated, that the safety strap and rear endgates are in place, and that the doors are closed before moving the vehicle.

7. All personnel should load and unload from the rear of the truck through the use of the steps or ladder. Loading and unloading by climbing on the sides of a cargo truck is dangerous, because a member may slip and fall. Additionally, the weight of personnel causes damage to the side racks.

NOTE: In the NCF, a common practice when loading and unloading passengers is to have the driver exit the cab and visually ensure that all personnel load and unload safely through the use of steps or ladders and ensure the required items are securely in place before proceeding.

Prohibited Practices

Prohibited practices, when engaged in the transporting of personnel, are as follows:

1. Avoid fueling with riders on board unless absolutely necessary.

2. Do not talk to riders or engage in any other distracting activities, while driving.

3. Do not tow or push a disabled bus with passengers aboard, unless unsafe conditions exist. In this case, do not discharge the passengers until the bus has been towed or pushed to the nearest safe area.

TAXI DRIVER

The taxi service provides a method of transporting personnel to medical appointments, jobsites, airports, and areas directed by the transportation supervisor. The dispatch office is normally the base station for taxi service, and the communication to the taxi driver is provided through the use of a radio.

When you are assigned taxi driver duties, the safety of the passengers is your responsibility. You should follow the same safety rules as outlined for hauling personnel in buses and cargo trucks.

TIME CARDS

Time cards are a labor accounting system used to record and measure the number of man-days that an NMCB spends on various functions. In this system, labor utilization data is collected daily in sufficient detail to enable the Operations Department to compile the data that supports the management of manpower resources and the preparation of reports to higher authority. The Daily Labor Distribution Report Form, COMCBPAC-GEN 5300/1 (fig. 6-23), is the form used when recording man-days expended. Although labor accounting systems may vary slightly from one unit to another, the system described here can be considered typical.

The type of labor performed is broken down and reported in a number of categories. The purpose of these categories is to show how well labor has been used. For time keeping and labor reporting, all labor is classified as productive or overhead.

PRODUCTIVE LABOR is all labor that directly or indirectly contributes to the accomplishment of the mission of the unit, such as construction operations, military operations and readiness, disaster recovery operations, and training.

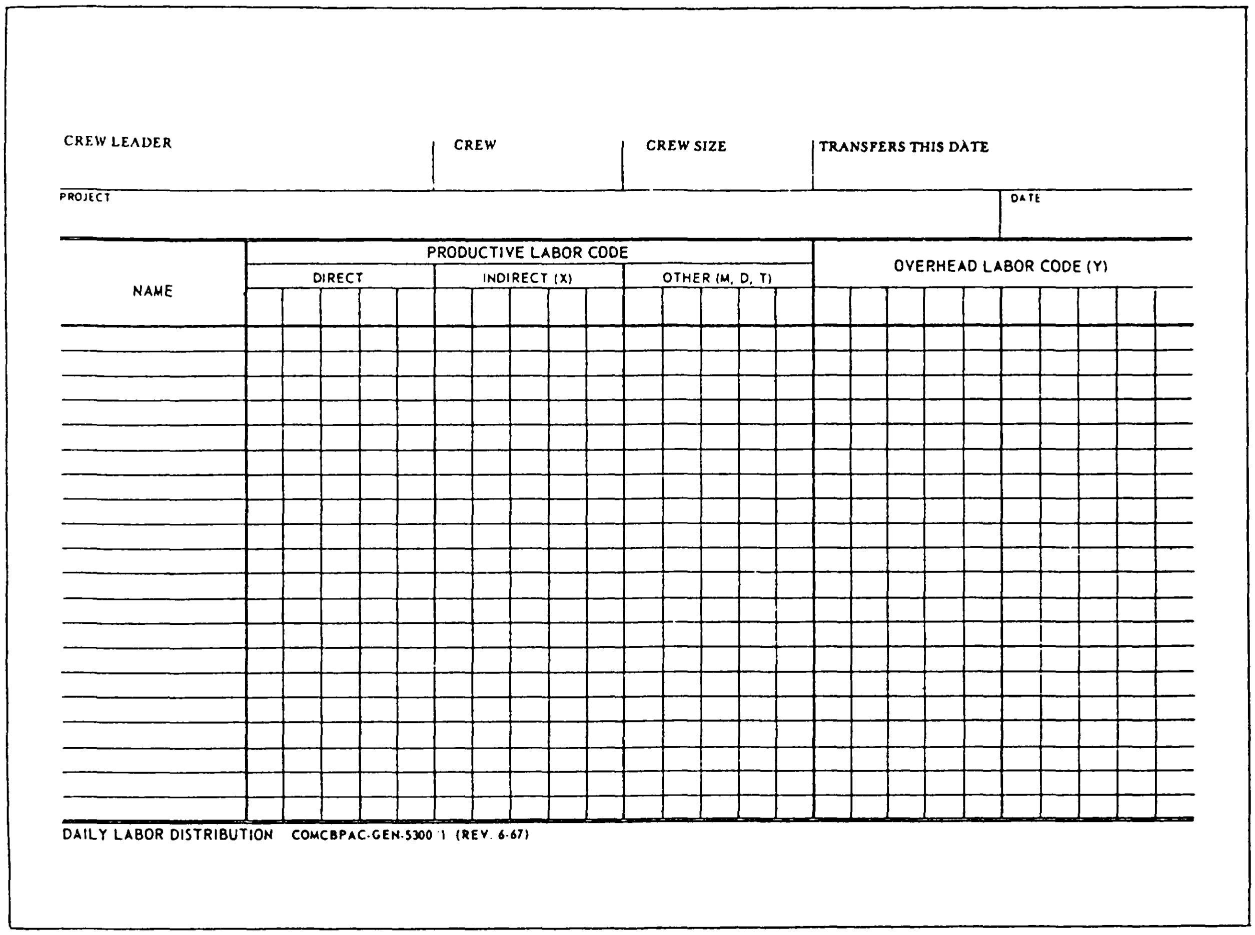
1. DIRECT LABOR is all man-days expended directly on assigned construction activity, either in the field or in the shop, and labor which contributes directly to the completion of the end product. Direct labor must be reported separately for each assigned master activity.

2. INDIRECT LABOR is man-days expended to support construction operations, but which does not produce an end product itself. Equipment maintenance and production of shop drawings are examples of indirect labor.

3. MILITARY OPERATIONS AND READINESS is man-days expended in actual military operations, unit embarkation, planning and preparation necessary to ensure the military and mobility readiness of the unit.

4. DISASTER RECOVERY OPERATIONS is man-days actually expended during disaster recovery operations.

OVERHEAD LABOR is not considered to be productive labor in that it does not contribute directly or indirectly to the end product. It includes all labor that



CREW LEADER | CREW | CREW SIZE | TRANSFERS THIS DATE

PROJECT | DATE

NAME | PRODUCTIVE LABOR CODE: DIRECT | INDIRECT (X) | OTHER (M, D, T) | OVERHEAD LABOR CODE (Y)

DAILY LABOR DISTRIBUTION COMCBPAC-GEN-5300/1 (REV. 6-67)

Figure 6-23.-Daily Labor Distribution Report Form.

must be performed regardless of the assigned mission. Subcategories of labor are shown in figure 6-24.

Crew leaders have the responsibility of preparing time cards each day to reflect man-hours expended by all personnel assigned to them. In the transportation pool, this may be the responsibility of the yard boss or the dispatcher.

The crew leader's report is submitted on a Daily Labor Distribution Report Form, as shown in figure 6-23. The report provides a breakdown by man-hours spent on a construction project or in the various labor codes for each person in the crew for any day on any project. It should be reviewed by the company operations chief and the company commander before it is forwarded to the Operations Department.

Operations Department tabulates the crew leader's report along with all of the daily labor distribution reports received from each company and department in the unit. It serves as the means by which the operations officer analyzes the labor distribution of his total manpower resources for any day as feeder information for the preparation of the monthly operations report and any other resource reports required of the unit.

This information must be accurate and timely, and each level in the company organization should review it for an analysis of its own internal construction management and performance rather than serve merely as a feeder report to the operations officer.

EMBARKATION

Naval Construction Force (NCF) units, such as Naval Mobile Construction Battalions (NMCBs), Amphibious Construction Battalions (PHIBCBs), Construction Battalion Units (CBUs), and so forth, are required to maintain a high state of readiness and must be capable of rapidly and efficiently embarking aboard aircraft or shipping to provide contingency support to the Navy, the Marine Corps, and other forces and perform and participate in disaster recovery operations and field exercises. Detailed procedures for embarkation are outlined in the *Naval Construction Force Embarkation Manual*, COMSECOND/ COMTHIRDNCBINST 3120.1.

CESE AND MATERIAL PREPARATION

Upon notification from higher authority to mount-out and deploy, the battalion re-organizes and sets up a mount-out control center (MOCC). The MOCC is under the direction of the battalion executive officer. The MOCC controls, coordinates, and monitors the movement of all personnel, supplies, and equipment to the marshaling area. The MOCC and the embarkation staff control all aspects of an NMCB mount-out and serve as the coordinating center for all the companies and battalion staff.

The preparation of CESE for embarkation is the responsibility of Alfa company. All vehicles and equipment must be absolutely clean of mud, oil, grease, or any other foreign matter, and all leaks must be repaired before being embarked. Embarking on aircraft requires special loading procedures for several types of CESE assigned to the battalion Table of Allowance (TOA). These procedures are outlined in the *NCF Embarkation Manual*, COMSECOND/ COMTHIRD-NCBINST 3120.1 Series. Alfa company has the responsibility of following these procedures that consist of the removal of dump truck headache racks, equipment exhaust stacks, dozer blades, counterweights, and equipment roll over protective structure (ROPS), bows, tarps and side racks, and so forth.

NOTE: The bolts, nuts, and parts from the disassembled equipment must be placed with the equipment in a location that is easily accessible.

Mobile Loads

A mobile load is an item on a vehicle that is not considered to be a secured part of a vehicle. Mobile-loaded items must be secured to the vehicle by a minimum of one-half-inch-thick rope of manila or hemp, from side to side and front to rear.

Onboard Fuel

Another area that must be checked and serviced is the amount of fuel in the fuel tanks on vehicles. Fuel tanks of a vehicle must be at least one-fourth full and not more than three-fourths full. If the vehicle is to be placed on the ramp of an aircraft, fuel tanks should never be more than one-half full.

Fuel in tanks for trailer-mounted and single-axle units must not exceed one-fourth full when these units are disconnected from the prime mover with the tongue resting on the aircraft floor. When positioned on the aircraft ramp, the fuel tanks must be drained, but not purged.

After a piece of CESE is cleaned, checked, and serviced by Alfa company, the dispatcher notifies the MOCC that the CESE is ready to be transferred to the

PRODUCTIVE LABOR. Productive labor includes all labor that directly contributes to the accomplishment of the Naval Mobile Construction Battalion, including construction operations and readiness, disaster recovery operations, and training.

DIRECT LABOR. This category includes all labor expended directly on assigned construction tasks, either in the field or in the shop, and which contributes directly to the completion of the end product.

INDIRECT LABOR. This category comprises labor required to support construction operations, but which does not produce in itself. Indirect labor reporting codes are as follows:

X01 Construction Equipment Maintenance, Repair and Records
X02 Operation and Engineering
X03 Project Supervision
X04 Project Expediting (Shop Planners)
X05 Location Moving
X06 Project Material Support
X07 Tool and Spare Parts Issue
X08 Other

MILITARY OPERATIONS AND READINESS. This category comprises all manpower expended in actual military operations, unit embarkation, and planning and preparations necessary to insure unit military and mobility readiness. Reporting codes are as follows:

M01 Military Operations
M02 Military Security
M03 Embarkation
M04 Unit Movement
M05 Mobility Preparation
M06 Contingency
M07 Military Administrative Functions
M08 Mobility & Defense Exercise
M09 Other

DISASTER CONTROL OPERATIONS

D01 Disaster Control Operations
D02 Disaster Control Exercise

TRAINING. This category includes attendance at service schools, factory and industrial training courses, fleet type training, and short courses, military training, and organized training conducted within the battalion. Reporting codes are as follows:

T01 Technical Training
T02 Military Training
T03 Disaster Control Training
T04 Leadership Training
T05 Safety Training
T06 Training Administration

OVERHEAD LABOR. This category includes labor which must be performed regardless of whether a mission is assigned, and which does not contribute to the assigned mission. Reporting codes are as follows:

Y01 Administrative & Personnel
Y02 Medical & Dental Department
Y03 Navy Exchange and Special Services
Y04 Supply & Disbursing
Y05 Commissary
Y06 Camp Upkeep & Repairs
Y07 Security
Y08 Leave & Liberty
Y09 Sickcall, Dental & Hospitalization
Y10 Personal Affairs
Y11 Lost Time
Y12 TAD not for unit
Y13 Other

Figure 6-24.-Subcategories of labor.

weighing and marking station. Weighing and marking procedures are outlined in the *Equipment Operator, Advanced,* NAVEDTRA 12537.

Palletized Cargo

Cargo that is to be loaded on an aircraft is palletized on 463-L air certified pallets, as shown in figure 6-25. The weight of an empty 463-L pallet is standardized at 290 pounds; when side and top nets are added the pallet weight is 355 pounds. These figures are to be used in weight and balance planning of an aircraft load plan. The outside dimensions of a 463-L pallet are 88 inches long and 108 inches wide. The usable space on the pallet is 84 by 104 inches; this leaves a 9-inch space around the outside perimeter of the pallet load. Cargo can be loaded on the pallet up to 96 inches high, and the weight limitation is 10,000 pounds per pallet maximum.

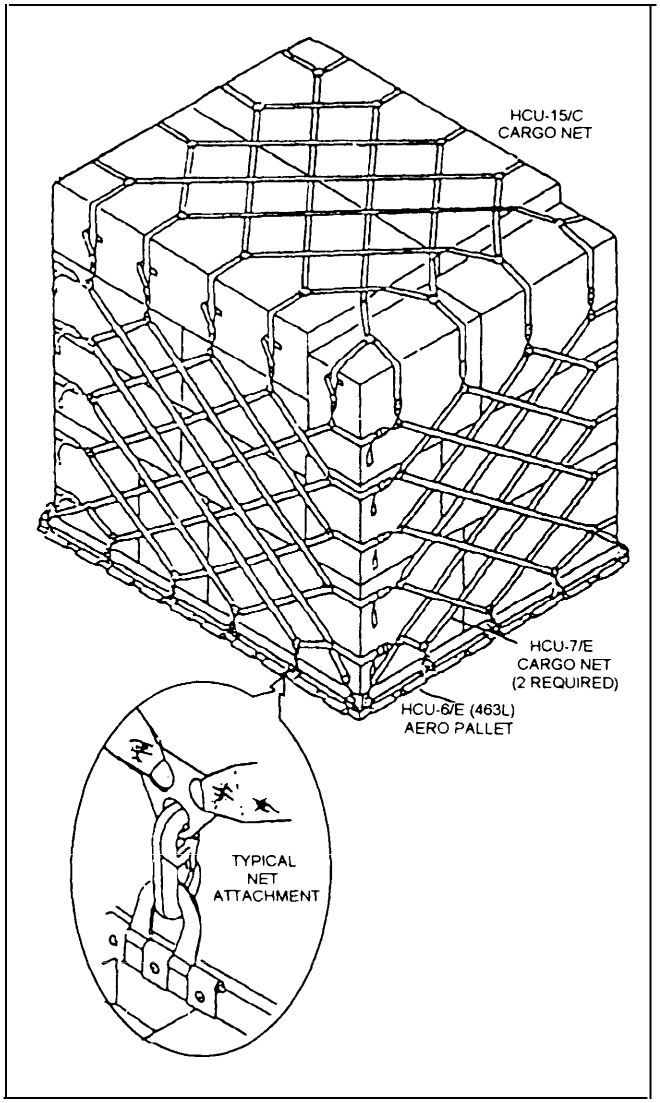


Figure 6-25.-463-L pallet with cargo and net.

Each pallet has a total of 22 tie-down rings (six on the long side and five on the short side) that match up with the cargo net fasteners. 463-L pallets lock into the aircraft by a rail on each side of the aircraft.

When loads are placed on a pallet, three point dunnage must be placed under each pallet. The size of the dunnage must be at least 4- by 4- by 88-inch timbers. One timber must be placed under the center of the pallet and one under each outside edge of the pallet; this helps prevent warping of the pallets.

To store empty pallets, you should first put down one set of three point dunnage, then stack the pallets no more than 10 high. If more pallets must be stacked, another set of dunnage must be placed on top of the first 10 pallets, then 10 more pallets can be stacked. This sequence can be repeated up to a maximum of 40 pallets. Each pallet must be stacked with the cargo loading surface facing in an upward direction.

During the pallet-building process (placing cargo on the pallets), always load heavy cargo in the center of the pallet and build it up with lighter cargo around it. This will keep the center of balance at the center of the pallet. All cargo loaded on a 463-L pallet must be placed close together with no open space between them. If space is left between cargo items, the cargo may shift on the pallet during flight and could cause damage to or even loss of the aircraft.

ADVANCED BASE PLANNING

During World War II when bases were constructed across the island chains of the Pacific Ocean, it became apparent that significant savings in both time and material could be realized if units of materials, equipment, and personnel required to perform specific functions were standardized. This was the beginning of the Advanced Base Functional Components (ABFC) System that is still in use today. This section will briefly cover the ABFC System and the *Facilities Planning Guide,* NAVFAC P-437.

ADVANCED BASE FUNCTIONAL COMPONENTS SYSTEM

The Advanced Base Functional Components System is covered in the *Naval Construction Force (NCF) Manual,* NAVFAC P-315, and in volume 2 of the *Facilities Planning Guide,* NAVFAC P-437. However, the overall ABFC System comprises a preplanned collection of individual functional components, each of which is designed and organized to perform a specific function at an advanced base. These functional components are given code numbers and names to indicate their function; for example, component P26 is a Seabee Team, and component N24A is a 750-man tent camp.

By using the ABFC System, planners for logistics, facilities, and construction can readily identify the equipment, facilities, materials, construction effort, and other pertinent information that is needed for each component. The basic document that identifies all of this data is the NAVFAC P-437.

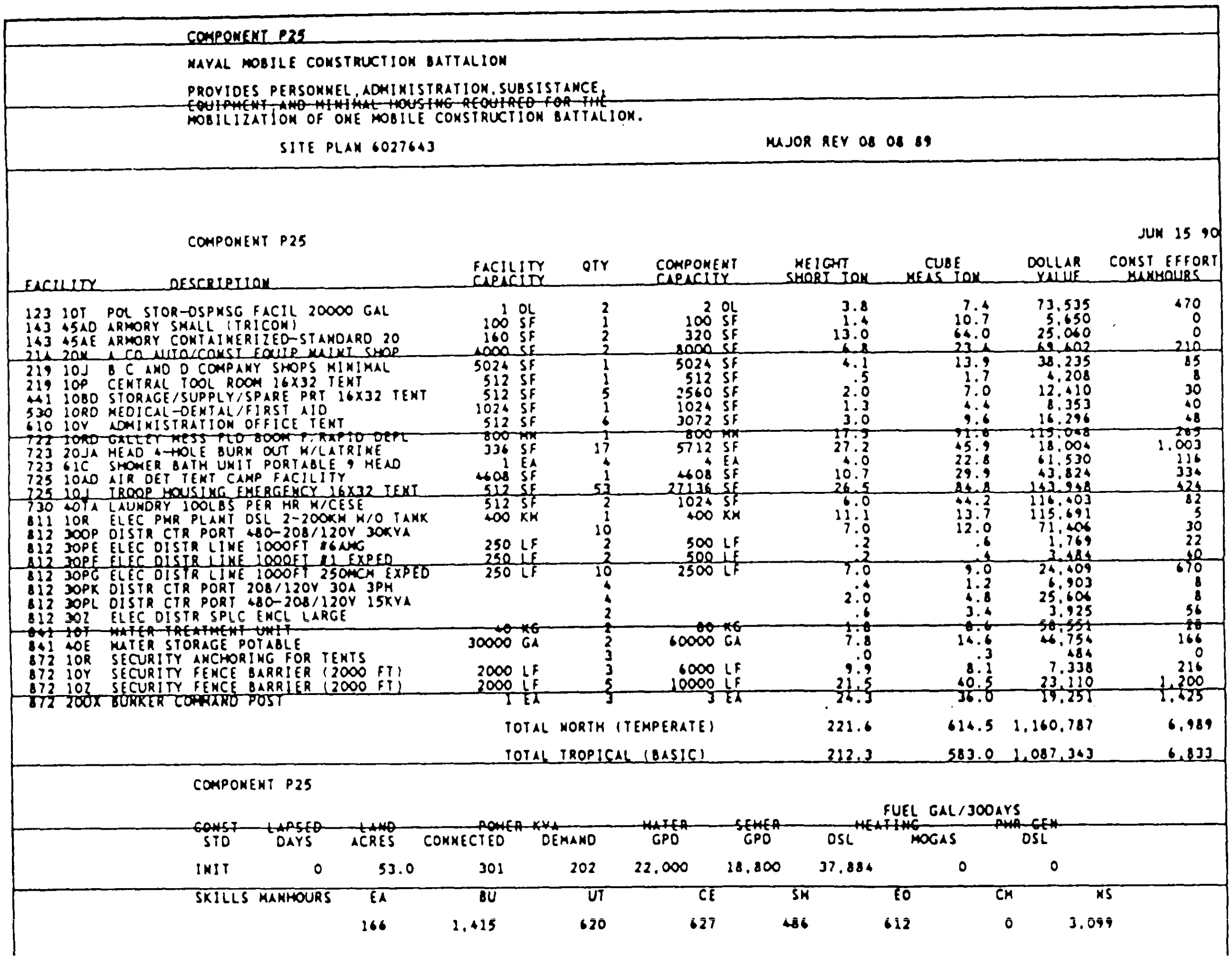
NAVFAC P-437

The *Facilities Planning Guide,* NAVFAC P-437, is the basic tool that you should consult when tasked to assist in planning the construction of an advanced base. This document identifies the structures and supporting utilities of the Navy ABFC System. It was developed to make pre-engineered facility designs and corresponding material lists available to planners at all levels. While these designs relate primarily to expected needs at advanced bases and to the Navy ABFC System, they can also be used to satisfy peacetime requirements. Facilities, logistics, and construction planners will each find the information required to select and document the material necessary to construct facilities.

NAVFAC P-437 consists of two volumes. Although it may seem unusual to do so, volume 2 will be covered first.

Volume 2

Volume 2 of the P-437 is organized into three parts. **Part 1 (Components)** contains data displays for each of the ABFC components and is indexed by code number. These data displays list and describe the **facilities** that make up each ABFC component. Figure 6-26 is an



COMPONENT P25

NAVAL MOBILE CONSTRUCTION BATTALION

PROVIDES PERSONNEL,ADMINISTRATION,SUBSISTANCE,
EQUIPMENT AND MINIMAL HOUSING REQUIRED FOR THE
MOBILIZATION OF ONE MOBILE CONSTRUCTION BATTALION.

SITE PLAN 6027643 MAJOR REV 08 08 89

COMPONENT P25 JUN 15 90

FACILITY	DESCRIPTION	FACILITY CAPACITY	QTY	COMPONENT CAPACITY	WEIGHT SHORT TON	CUBE MEAS TON	DOLLAR VALUE	CONST EFFORT MANHOURS
123 10T	POL STOR-DSPNSG FACIL 20000 GAL	1 OL	2	2 OL	3.8	7.4	73,535	470
143 45AD	ARMORY SMALL (TRICON)	100 SF	1	100 SF	1.4	10.7	5,650	0
143 45AE	ARMORY CONTAINERIZED-STANDARD 20	160 SF	2	320 SF	13.0	64.0	25,060	0
214 20N	A CO AUTO/CONST EQUIP MAINT SHOP	4000 SF	2	8000 SF	6.8	23.4	69,602	210
219 10J	B C AND D COMPANY SHOPS MINIMAL	5024 SF	1	5024 SF	4.1	13.9	38,235	85
219 10P	CENTRAL TOOL ROOM 16X32 TENT	512 SF	1	512 SF	.5	1.7	4,208	8
441 10BD	STORAGE/SUPPLY/SPARE PRT 16X32 TENT	512 SF	5	2560 SF	2.0	7.0	12,410	30
530 10RD	MEDICAL-DENTAL/FIRST AID	1024 SF	1	1024 SF	1.3	4.4	8,353	40
610 10V	ADMINISTRATION OFFICE TENT	512 SF	6	3072 SF	3.0	9.6	16,296	48
722 10RD	GALLEY MESS FLD 800M F/RAPID DEPL	800 MN	1	800 MN	17.5	91.6	115,048	265
723 20JA	HEAD 4-HOLE BURN OUT W/LATRINE	336 SF	17	5712 SF	27.2	45.9	18,004	1,003
723 61C	SHOWER BATH UNIT PORTABLE 9 HEAD	1 EA	4	4 EA	4.0	22.8	61,530	116
725 10AD	AIR DET TENT CAMP FACILITY	4608 SF	1	4608 SF	10.7	29.9	43,824	334
725 10J	TROOP HOUSING EMERGENCY 16X32 TENT	512 SF	53	27136 SF	26.5	84.8	143,948	424
730 40TA	LAUNDRY 100LBS PER HR W/CESE	512 SF	2	1024 SF	6.0	44.2	116,403	82
811 10R	ELEC PWR PLANT DSL 2-200KW W/O TANK	400 KW	1	400 KW	11.1	13.7	115,691	5
812 30OP	DISTR CTR PORT 480-208/120V 30KVA		10		7.0	12.0	71,406	30
812 30PE	ELEC DISTR LINE 1000FT #6AWG	250 LF	2	500 LF	.2	.6	1,769	22
812 30PF	ELEC DISTR LINE 1000FT #1 EXPED	250 LF	2	500 LF	.2	.4	3,484	40
812 30PG	ELEC DISTR LINE 1000FT 250MCM EXPED	250 LF	10	2500 LF	7.0	9.0	24,409	670
812 30PK	DISTR CTR PORT 208/120V 30A 3PH		4		.4	1.2	6,903	8
812 30PL	DISTR CTR PORT 480-208/120V 15KVA		4		2.0	4.8	25,606	8
812 30Z	ELEC DISTR SPLC ENCL LARGE		2		.6	3.4	3,925	56
841 10T	WATER TREATMENT UNIT	40 KG	2	80 KG	1.8	8.6	58,551	28
841 40E	WATER STORAGE POTABLE	30000 GA	2	60000 GA	7.8	14.6	46,754	166
872 10R	SECURITY ANCHORING FOR TENTS		3		.0	.3	484	0
872 10Y	SECURITY FENCE BARRIER (2000 FT)	2000 LF	3	6000 LF	9.9	8.1	7,338	216
872 10Z	SECURITY FENCE BARRIER (2000 FT)	2000 LF	5	10000 LF	21.5	40.5	23,110	1,200
872 200X	BUNKER COMMAND POST	1 EA	3	3 EA	24.3	36.0	19,251	1,425
	TOTAL NORTH (TEMPERATE)				221.6	614.5	1,160,787	6,989
	TOTAL TROPICAL (BASIC)				212.3	583.0	1,087,343	6,833

COMPONENT P25

CONST STD	LAPSED DAYS	LAND ACRES	POWER KVA CONNECTED	POWER KVA DEMAND	WATER GPD	SEWER GPD	FUEL GAL/30DAYS HEATING DSL	FUEL GAL/30DAYS HEATING MOGAS	FUEL GAL/30DAYS PWR GEN DSL
INIT	0	53.0	301	202	22,000	18,800	37,884	0	0

SKILLS MANHOURS	EA	BU	UT	CE	SW	EO	CM	WS
	166	1,415	620	627	486	612	0	3,099

Figure 6-26.-Typical data display for a component.

example of one of the data displays that you can find in part 1.

Take note that figure 6-26 is for component P25. The name of this component is Naval Mobile Construction Battalion. The specific function, or purpose, of this component is shown directly below the component name. Listed below the function are all of the facilities that comprise component P25. For each facility, you find the single-facility capacity, total quantity, and total facility capacity required for the component; for example, there is a total of two water-storage facilities (Facility Number 841 40E) required for the complete component. Each of these storage facilities has a capacity of 30,000 gallons, and the total water-storage capacity for the component is 60,000 gallons. Also listed for each facility is the weight, cube, dollar value, and estimated construction effort for the total quantity of each facility. At the bottom of figure 6-26, you find additional information concerning the complete component. This includes a breakdown, by Seabee rating, of the estimated direct-labor man-hours that are needed to construct the component.

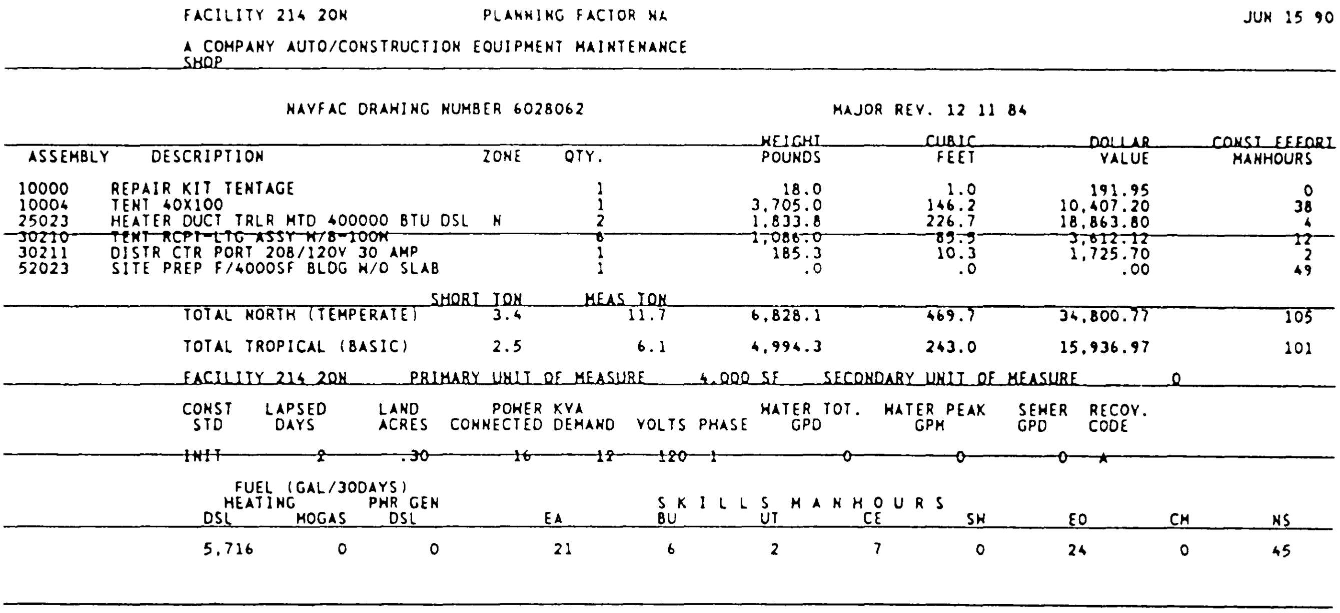
Part 2 (Facilities) includes a data display for each of the ABFC facilities. This part, indexed by facility number, is used to identify the **assemblies** that are required for each facility. For the P25 component, look at the data display for Facility Number 214 20N. This data display, found in part 2, is shown in figure 6-27.

At the top of this data display (fig. 6-27) is the facility number and nomenclature of the facility. Below this, you see a listing, by assembly number, of all of the assemblies that are needed for one complete facility. This listing includes the description, quantity, weight, cubic feet, dollar value, and the estimated construction effort required for each assembly. Below the listing of assemblies, you also find other information regarding the complete facility; for example, you can see that Facility 214 20N requires a land area of .30 acres and the estimated EO direct labor required to install this facility is 24 man-hours.

Part 3 (Assemblies) is indexed by assembly number and contains data displays that list all of the materials required for each assembly. For an example, look at the data display for Assembly Number 10004 that is required for Facility 214 20N shown in figure 6-28. This display shows the national stock number (NSN), description, unit of issue, quantity, weight, cubic feet, and dollar value for each line item of material that is required for one complete assembly. Additionally, you can find the estimated number of man-hours and the recommended size of crew needed to assemble and install one of these assemblies.

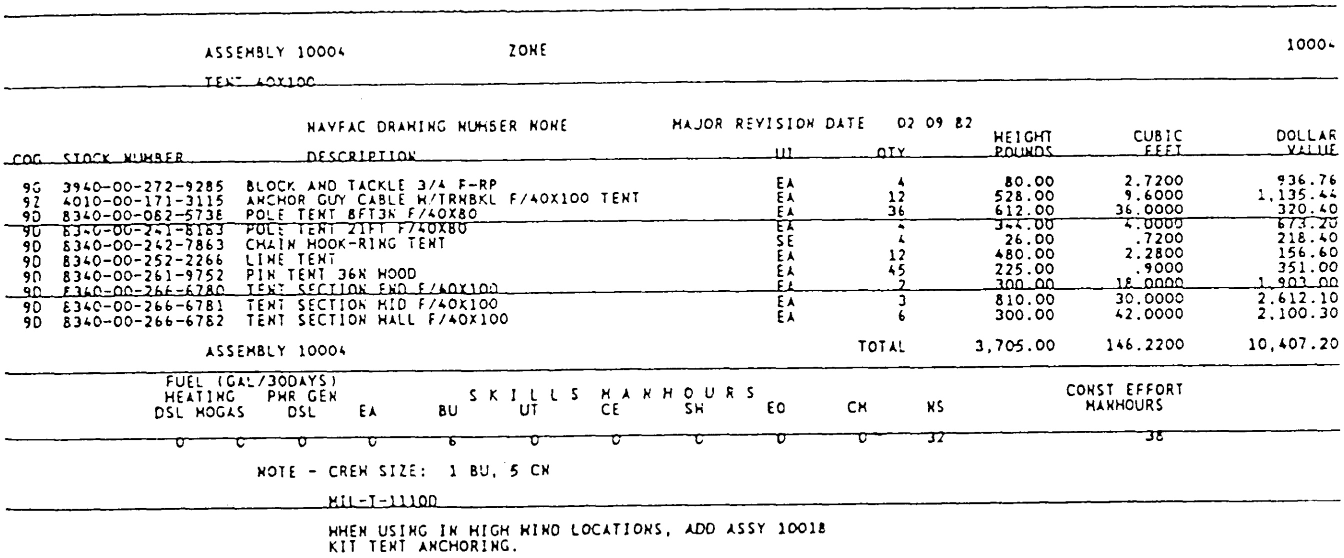
Volume 1

Refer again to figures 6-26, 6-27, and 6-28. Each of these figures references to a drawing. Volume 1 of



```
                FACILITY 214 20N            PLANNING FACTOR NA                                                JUN 15 90
                A COMPANY AUTO/CONSTRUCTION EQUIPMENT MAINTENANCE
                SHOP
---------------------------------------------------------------------------------------------------------------------------
                      NAVFAC DRAWING NUMBER 6028062                  MAJOR REV. 12 11 84
---------------------------------------------------------------------------------------------------------------------------
                                                                       WEIGHT         CUBIC          DOLLAR     CONST EFFORT
 ASSEMBLY    DESCRIPTION                      ZONE    QTY.             POUNDS          FEET           VALUE       MANHOURS

 10000     REPAIR KIT TENTAGE                           1               18.0            1.0          191.95              0
 10004     TENT 40X100                                  1            3,705.0          146.2       10,407.20             38
 25023     HEATER DUCT TRLR MTD 400000 BTU DSL  N       2            1,833.8          226.7       18,863.80              4
 30210     TENT RCPT-LTG ASSY W/8-100W                  6            1,086.0           85.5        3,612.12             12
 30211     DISTR CTR PORT 208/120V 30 AMP               1              185.3           10.3        1,725.70              2
 52023     SITE PREP F/4000SF BLDG W/O SLAB             1                 .0             .0             .00             49

                                           SHORT TON      MEAS TON
---------------------------------------------------------------------------------------------------------------------------
                TOTAL NORTH (TEMPERATE)       3.4            11.7        6,828.1          469.7       34,800.77            105

                TOTAL TROPICAL (BASIC)        2.5             6.1        4,994.3          243.0       15,936.97            101

                FACILITY 214 20N      PRIMARY UNIT OF MEASURE      4,000 SF     SECONDARY UNIT OF MEASURE         0
---------------------------------------------------------------------------------------------------------------------------
                CONST    LAPSED      LAND        POWER KVA                          WATER TOT.  WATER PEAK   SEWER  RECOV.
                 STD      DAYS      ACRES    CONNECTED DEMAND   VOLTS PHASE          GPD          GPM        GPD    CODE

                INIT         2        .30          16        12    120   1             0            0          0   *

                     FUEL (GAL/30DAYS)
                   HEATING         PWR GEN                          S K I L L S   M A N H O U R S
                  DSL      MOGAS    DSL               EA           BU        UT        CE        SW        EO        CM        NS
---------------------------------------------------------------------------------------------------------------------------
                  5,716        0       0              21            6         2         7         0        24         0        45

---------------------------------------------------------------------------------------------------------------------------
```

Figure 6-27.-Typical data display for a facility.



```
                ASSEMBLY 10004             ZONE                                                              10004
                TENT 40X100
                         NAVFAC DRAWING NUMBER NONE         MAJOR REVISION DATE   02 09 82
                                                                                      WEIGHT        CUBIC         DOLLAR
COG  STOCK NUMBER        DESCRIPTION                               UI        QTY       POUNDS        FEET          VALUE

9G   3940-00-272-9285    BLOCK AND TACKLE 3/4 F-RP                 EA          4        80.00       2.7200         936.76
9Z   4010-00-171-3115    ANCHOR GUY CABLE W/TRNBKL F/40X100 TENT   EA         12       528.00       9.6000       1,135.44
9D   8340-00-082-5738    POLE TENT 8FT3N F/40X80                   EA         36       612.00      36.0000         320.40
9D   8340-00-241-8163    POLE TENT 21FT F/40X80                    EA          4       344.00       4.0000         673.20
9D   8340-00-242-7863    CHAIN HOOK-RING TENT                      SE          4        26.00        .7200         218.40
9D   8340-00-252-2266    LINE TENT                                 EA         12       480.00       2.2800         156.60
9D   8340-00-261-9752    PIN TENT 36N WOOD                         EA         45       225.00        .9000         351.00
9D   8340-00-266-6780    TENT SECTION END F/40X100                 EA          2       300.00      18.0000       1,903.00
9D   8340-00-266-6781    TENT SECTION MID F/40X100                 EA          3       810.00      30.0000       2,612.10
9D   8340-00-266-6782    TENT SECTION WALL F/40X100                EA          6       300.00      42.0000       2,100.30

                ASSEMBLY 10004                                          TOTAL     3,705.00     146.2200      10,407.20

           FUEL (GAL/30DAYS)
           HEATING   PWR GEN               S K I L L S  M A N H O U R S                                CONST EFFORT
          DSL MOGAS    DSL      EA      BU      UT      CE      SW      EO      CM      NS               MANHOURS

            0     0     0        0       6       0       0       0       0       0      32                   38

                    NOTE - CREW SIZE:  1 BU, 5 CM
                           MIL-T-11100
                           WHEN USING IN HIGH WIND LOCATIONS, ADD ASSY 10018
                           KIT TENT ANCHORING.
```

Figure 6-28.—Typical data display for an assembly.

the P-437 is used for these drawings. Volume 1 contains reproducible engineering drawings and is organized as follows:

Part 1 (Component Site Plans) is indexed by component designation and includes typical site plans for the ABFC components. When a component does not have a site plan, the word *None* appears on the data display for the component.

Part 2 (Facility Drawings and Networks) is indexed by facility number and contains detailed construction drawings of the ABFC facilities. Also included in part 2 preconstruction networks. A network is a diagram that is used to guide and manage a construction project. It includes information, such as the sequence of construction activities, start and finish dates of each construction activity, duration of each activity, and other information that is of use to the crew leaders, supervisors, and managers of a project. The *Seabee Planner's and Estimator's Handbook,* NAVFAC P-405, provides detailed guidance on reading and preparing construction networks.

Part 3 (Assembly Drawings) contains working drawings of the ABFC assemblies. It is indexed by assembly number.

The above is only a brief overview of Advanced Base Functional Components. For more information, you should refer to the NAVFAC P-437, Volume 2.

CHAPTER 7

TRACTOR-TRAILERS AND DUMP TRUCKS

Tractor-trailers and dump trucks are used to haul equipment, construction supplies, and materials used to support construction operations, disaster recovery operations, the preventive maintenance program, and so forth. This chapter covers the basic principles of tractor-trailer and dump truck operations.

TRACTOR-TRAILERS

Thousands of miles of tractor-trailer operations are generated during a deployment. These operations include the hauling of equipment and construction supplies in support of NMCB/NCF tasking. You, as an operator, must remember that when tractor-trailers are on the open road, they represent the U.S. Navy and the Seabees to the public.

The tractor, technically known as a **truck-tractor,** may have a gasoline- or diesel-powered engine, be equipped with an automatic or manual transmission, and range in capacity from 5 tons through 25 tons. Some examples are shown in figure 7-1.

NOTE: Because of the variety of transmission types in truck-tractors used by the NCF, it is important that you study the operator's manual before operating a certain model of truck-tractor. The operator manuals are located in the Technical Library.

Operator's errors, such as grinding gears while shifting, clutch slipping, rapid engagement during shifting, improper downshifting, and so forth, often cause premature failure of drive-line components, resulting in needless downtime and delays in production.

TYPES OF TRAILERS

The NCF uses a variety of trailers to support the mission of the NMCB. Before using any trailer, know all safety precautions, and check the manufacturer's recommendations for loading requirements, and weight restrictions. This is important because the OPERATOR IS RESPONSIBLE for the safe loading, securing, and operation of the tractor-trailer.

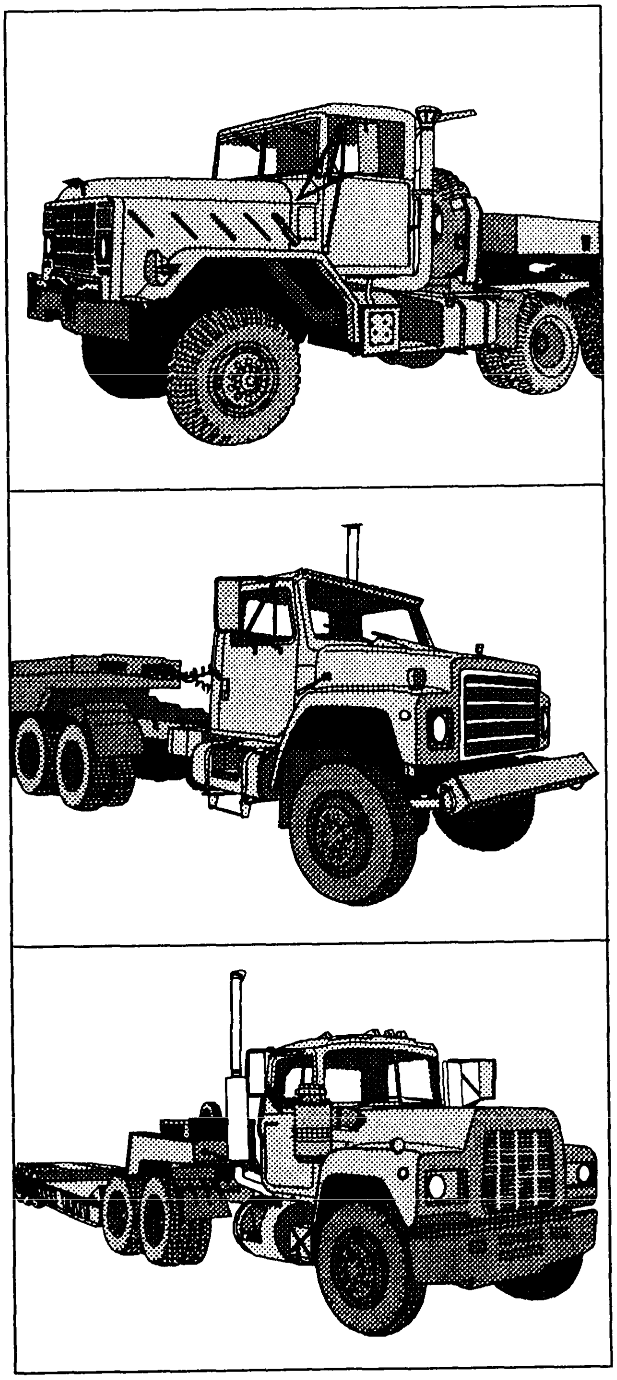


Figure 7-1.—Truck-tractors.

Van Trailer

A van trailer (fig. 7-2) is fully enclosed with permanent sides and top to keep the inside of the trailer dry and is manufactured with two basic types of doors. One type is the swing open and the other is the roll-up. In some cases, a trailer may have another door on the side. In the NCF, some of the van trailers have been modified to carry different types of cargo.

You may have to operate a refrigerated van trailer. The construction of a refrigerated van trailer is similar to the van, except it has a self-contained refrigeration unit built onto it.

Stake Trailer

The stake trailer (fig. 7-3) is often identified by the term **flatbed** and is designed for cargo that cannot fit

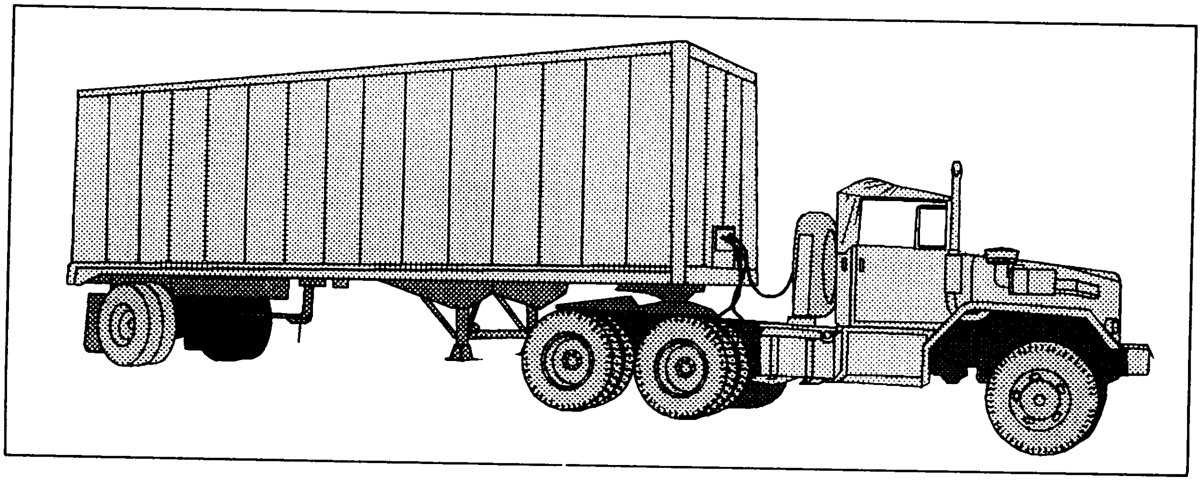


Figure 7-2.—Van trailer.

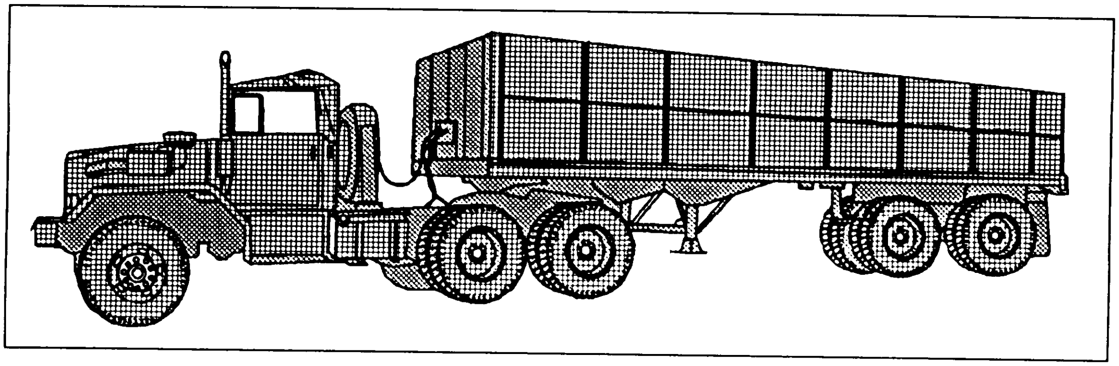


Figure 7-3.—Stake trailer.

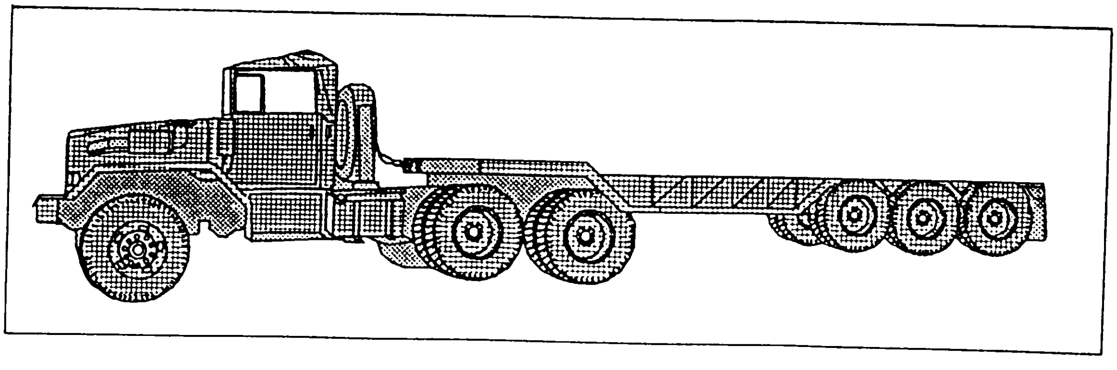


Figure 7-4.—Low-bed trailer.

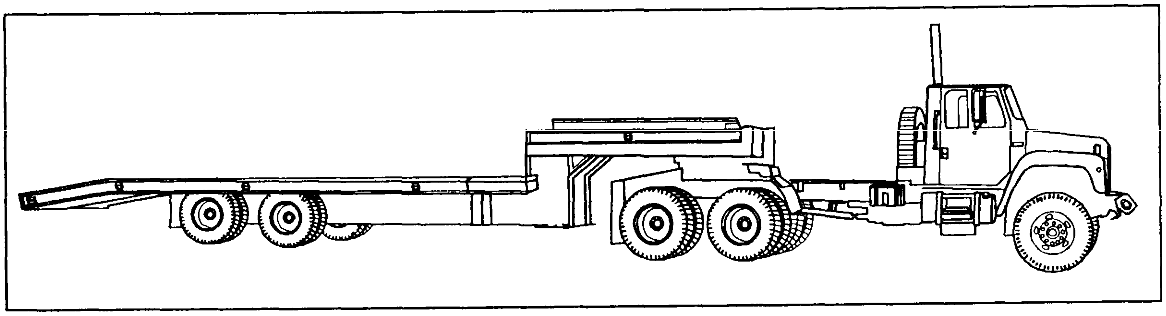


Figure 7-5.—Tilt-bed trailer.

through the doors of a van trailer. Stake trailers are easy to load and unload with forklifts from the side when the side stakes are removed. Any loads that extend over the width or length of the flatbed must be visually marked with a flag during the day and lights at night.

NOTE: Side stakes are collateral equipage for the stake trailer. The operator is responsible for the side stakes if they are removed, broken, or lost. When the side stakes are removed for storage, ensure the stakes are tagged with the USN number of the trailer. Damaged, lost, and in some cases stolen stakes should be reported immediately through your chain of command.

Low-Bed Trailer

The low-bed trailer (fig. 7-4) is often identified by the term **lowboy.** This trailer is used for hauling heavy equipment and material that is overheight and overweight for stake trailers. Low-bed trailers are heavily constructed to handle loads of 35 tons or more.

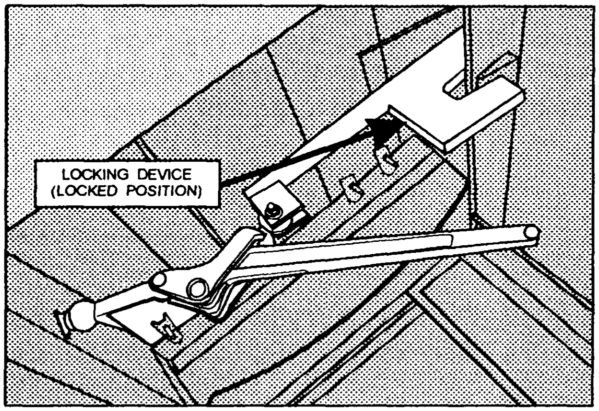
Tilt-Bed Trailer

The tilt-bed trailer (fig. 7-5) is often identified by the term **tilt-top** and is designed to tilt toward the rear for ease of loading and unloading without the use of ramps. Tilt-beds are primarily used to haul equipment; however, they also are used to transport construction materials and supplies.

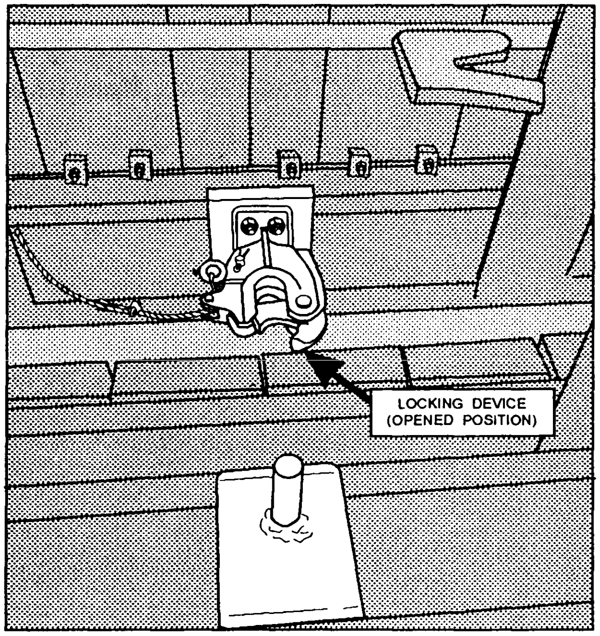
To avoid damaging equipment and trailers, you should remember the following rules:

1. Do not attempt to load heavy equipment on a tilt-bed trailer from a loading ramp or a dock.

2. Before loading heavy equipment on a tilt-bed trailer, you should ensure the locking mechanism (fig. 7-6) is fully disengaged.



PRIMARY LOCKING DEVICE
(LOCKED POSITION)



SECONDARY LOCKING DEVICE
(OPENED POSITION)

Figure 7-6.—Tilt-bed deck-locking mechanism.

3. When the tilt-bed trailer is in the tilt position, you should ensure the rear of the bed is resting on even ground.

4. Do not place heavy loads beyond the deck hinge.

5. Failure to follow the above rules can result in severe damage to the tilt-bed trailer and to the locking mechanism.

Detachable Gooseneck Trailer

The detachable gooseneck trailer (fig. 7-7) is often identified by the term **drop neck** and is designed so the gooseneck can be removed, leaving the front of the frame resting on the ground (fig. 7-8). This feature allows equipment to be loaded readily, using short ramps (usually hinged to the deck) or small blocks.

PRESTART INSPECTION

The primary reason for performing a prestart inspection is to ensure your tractor-trailer is safe. When performing your prestart inspection, you should use the same procedure each time. If you do so, you will be less likely to forget anything. A prestart inspection aid is shown in figure 7-9.

The following prestart inspection can be used as a procedure when performing prestart on all automotive equipment. All problems should be documented on the "Hard Card" NAVFAC 9-11240/13 and repaired as required. Do not operate any equip ment that does not meet safety standards. All safety features must be in operational order before any piece of equipment is used.

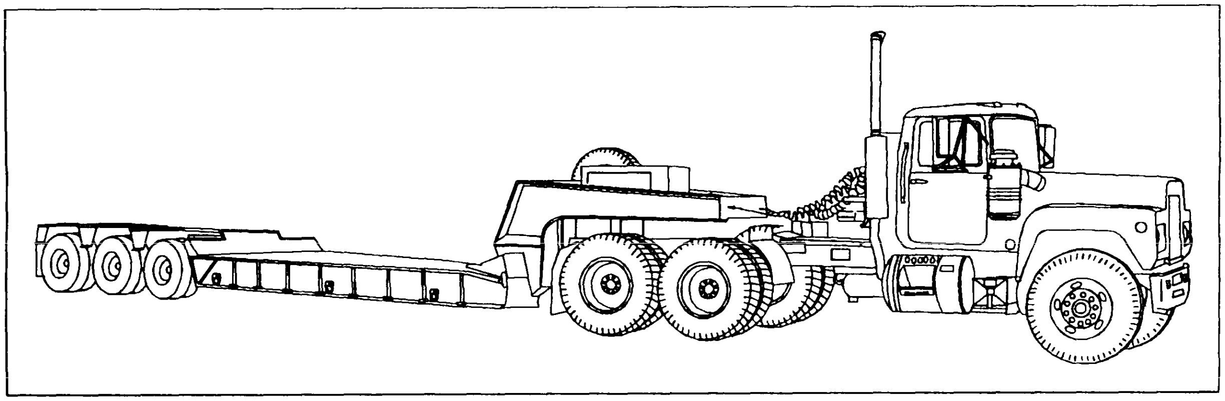


Figure 7-7.—Detachable gooseneck trailer

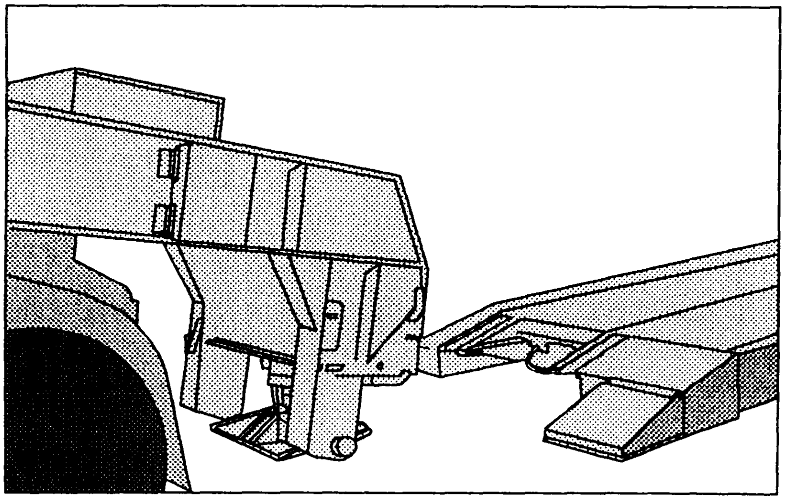


Figure 7-8.—Detached gooseneck from trailer.

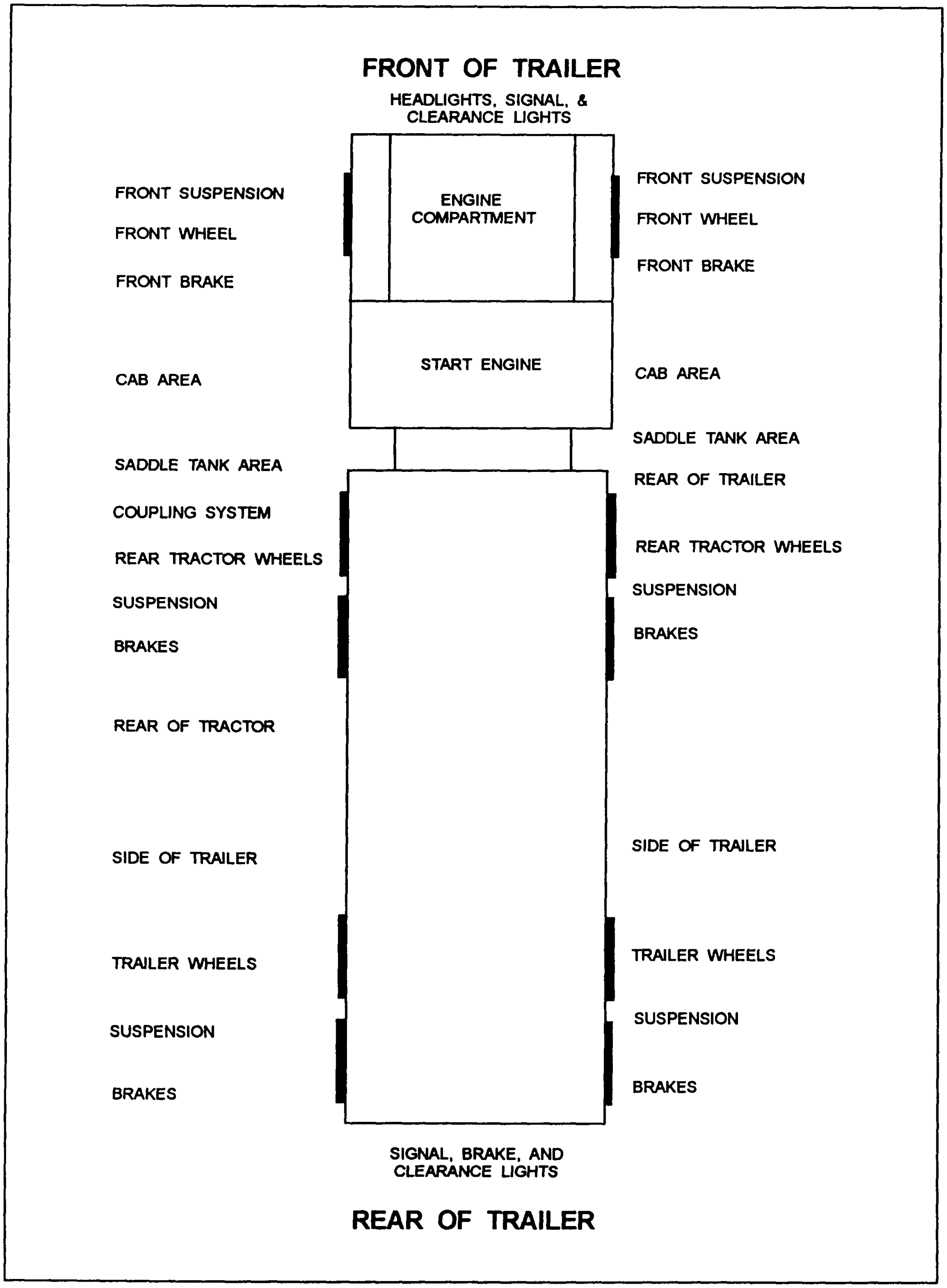

FRONT OF TRAILER
HEADLIGHTS, SIGNAL, & CLEARANCE LIGHTS
FRONT SUSPENSION
FRONT WHEEL
FRONT BRAKE
ENGINE COMPARTMENT
FRONT SUSPENSION
FRONT WHEEL
FRONT BRAKE
CAB AREA
START ENGINE
CAB AREA
SADDLE TANK AREA
REAR OF TRAILER
SADDLE TANK AREA
COUPLING SYSTEM
REAR TRACTOR WHEELS
SUSPENSION
BRAKES
REAR TRACTOR WHEELS
SUSPENSION
BRAKES
REAR OF TRACTOR
SIDE OF TRAILER
SIDE OF TRAILER
TRAILER WHEELS
SUSPENSION
BRAKES
TRAILER WHEELS
SUSPENSION
BRAKES
SIGNAL, BRAKE, AND CLEARANCE LIGHTS
REAR OF TRAILER

Figure 7-9.—Tractor-trailer prestart inspection aid.

Vehicle Overview

When you approach the tractor-trailer, take note of the general condition. Look for damage or if the vehicle is leaning to one side. Look under the vehicle for fresh oil, coolant, grease, or fuel leaks. You should check the area around the vehicle for people, objects, low hanging wires, and tree limbs which could present a hazard when the vehicle is moved.

Look inside the cab and ensure the parking brakes are engaged. For added safety, a set of wheel chocks should be in place around one of the tires.

NOTE: In the NCF, all 2 ton and above vehicles must have a set of wheel chocks that are used when the vehicle is parked.

Engine Compartment

You may have to raise the hood, tilt the cab (secure loose items so they cannot fall), or open the engine compartment door.

Check the following:

- Engine oil level.
- Coolant level in radiator; condition of hoses.
- Power steering fluid level; hose condition (if so equipped).
- Windshield washer fluid level.
- Battery fluid level, connection, and tiedown (batteries may be located in a separate compartment).
- Automatic transmission fluid level (may require a check with the engine warm and running).
- Check belts for tightness and excessive wear (alternator or generator, water pump, and air compressor).
- Leaks (fuel, coolant, oil, power steering fluid, hydraulic fluid, and battery fluid).
- Cracked or worn electrical wiring insulation.
- When checks are completed, you should lower and secure the hood, cab, or engine compartment door.

Walk Around Inspection

When you perform the walk around inspection, turn on the headlights, four-way hazard warning flashers, parking, clearance, side marker, and identification lights. Clean all lights, reflectors, and glass as you go along. Do not forget to check your brake and left and right turn signal lights. If a light bulb is not working, the yard boss normally has spare bulbs and tools that allows you to replace faulty bulbs.

LEFT FRONT.— On the left front of the tractor, inspect the following:

- Check the glass on the driver's door and ensure it is clean.
- Check and ensure the door latches or locks work properly.
- Check the left front wheel for the condition of the wheel and rim, such as missing, bent, broken studs, clamps, lugs, or any signs of misalignment.
- Check the condition of the tire for proper inflation, valve stem and cap are in place, serious cuts, bulges, and tread wear.
- Check the lug nuts for looseness and rust streaks.
- Check the condition of the spring, spring hanger, shackles, and U-bolts on the left front suspension.
- Check the condition of the brake drum(s) and condition of the brake hoses on the left front brake.

FRONT.— On the front of the tractor, inspect the following:

- Condition of the front axle.
- Condition of the steering system for such things as loose, worn, bent, damaged, or missing parts. Grab the steering mechanism and check for looseness.
- Condition of the windshield for damage and dirt.
- Condition of the windshield wiper arms for proper spring tension.
- Condition of the wiper blades for damage, rubber stiffness, and securement.
- Condition of lights and reflectors, such as the parking, clearance, and identification lights. Ensure they are clean, operating, and are the proper color (amber at front).

- Condition of the right turn signal. Ensure it is clean, operating, and is the proper color (amber or white on signals facing forward).

RIGHT SIDE.— On the right front, inspect all the items as you did on the left front. On the right side, inspect the following:

- Ensure the primary and safety cab locks are engaged (if cab-over design).
- Inspect the fuel tank(s) for damage, leaks, and secure mounting. Check the fuel crossover line, fuel level in the tank(s), and ensure the fuel cap(s) is/are on and secured.
- Inspect the rear of the engine for leaks.
- Inspect for leaks around the transmission.
- Ensure the exhaust system is secured and not leaking, touching wires, fuel, or air lines.
- Inspect for bends or cracks in the frame and cross members.
- Inspect air lines and electrical wiring and secure against snagging, rubbing, and wearing.
- Inspect the spare tire carrier for damage, and inspect the spare tire for proper inflation and size. Ensure the spare tire is secured in the tire carrier.

When hauling a load, inspect the following:

- Ensure the cargo is properly blocked, braced, tied, chained, and so forth.
- Ensure the header board is adequate and secured (if so equipped).
- Ensure the side racks, if equipped, are free of damage, properly set in place, and are secured.
- Ensure the canvas and tarp (if required) are properly secured to prevent tearing, billowing, or blockage of mirrors.
- Ensure all required signs are safely and properly mounted and all required permits are in your possession if the load is oversized.
- Ensure the curbside cargo door is securely closed, latched, locked, and so forth.

RIGHT REAR.— When inspecting the right rear of the vehicle, inspect the following:

- Check the condition of the wheels and rims for missing, bent, broken spacers, studs, clamps, and lugs.
- Check the condition of the tires for proper inflation, valve stem and caps, serious cuts, bulges, and tread wear.
- Ensure the tires are not rubbing against each other and that nothing is stuck between them, such as rocks, boulders, and mud.
- Ensure the tires are the same size and are not mixed, such as radial and bias types. Ensure all tires are properly inflated.
- Inspect the wheel bearings and seals for leaks.
- Check the hub oil level (if so equipped) and the hub oil reservoir for leaks.
- Inspect the suspension system, such as the condition of the springs, spring hangers, shackles, and U-bolts.
- Ensure the axle is secured and no fluid is leaking from it.
- Check the condition of the torque rod arms, bushings, and shock absorbers.
- Check the condition of the brakes, such as condition of the brake drums and undue wear on the hoses.
- Check the condition of lights and reflectors. Ensure they are clean, are operating, and are the proper color (red at rear, other amber), and that side-marker reflectors are clean and are the proper color (red at rear, others amber).

REAR.— When inspecting the rear of the vehicle, inspect the following:

- Ensure the rear clearance light, identification light, taillights and reflectors are clean, operating, and are the proper color (red at rear). Ensure that all wiring is secured in place.
- Ensure the right rear turn signal is clean, operational, and is the proper color (red, yellow, or amber at the rear).
- Ensure the license plate(s) is clean and secure (if so equipped).
- Ensure all required splash guards are present, not damaged, properly fastened, and not rubbing the tires or the ground.

When hauling a load with the vehicle, inspect the following:

- Ensure all cargo is properly blocked, braced, tied, chained, and so forth.
- Ensure the tailboards are up and properly secured (if so equipped).
- Ensure the rear doors are securely closed, latched, or locked.

LEFT SIDE.— When inspecting the left side, you inspect all items the same as on the right side, plus the following:

- Ensure the battery box (if not located in the engine compartment) is securely mounted to the vehicle.
- Ensure the battery box cover is secured.
- Ensure the batteries are secured.
- Ensure the batteries are not broken or leaking, and the fluid level in the battery is at the proper level.
- Ensure the battery cell caps are present and are securely tightened.
- Ensure the vents in the cell caps are free of foreign material.

Cab Inspection

You begin the cab inspection by ensuring the parking brake is on and the transmission is in neutral or park, if automatic. Start the engine and listen for unusual noises. Allow the engine to warmup properly. This takes between 3 to 5 minutes.

GAUGES.— Look at the gauges, such as the oil pressure, ammeter and/or voltmeter, coolant temperature, and engine oil temperature. These systems should come up to read normal within seconds after the engine has started. Warning lights and buzzers for oil, coolant, and charging system should go out once the system registers normal.

CONTROLS.— Check the condition of the following for looseness, sticking, damage, or improper setting:

- Steering wheel
- Clutch
- Accelerator pedal
- Brake controls, such as foot brakes, trailer brakes, parking brakes, and retarder controls
- Transmission controls
- Inner axle differential lock (if so equipped)
- Horn(s)
- Windshield wiper/washer
- Lights, such as headlights, dimmer switch, turn signals, four-way flashers, clearance, identification, and marker lights

MIRRORS AND WINDSHIELD.— Inspect mirrors for cracks, dirt, looseness, and obstructions. Clean, tighten, and adjust as necesary.

EMERGENCY EQUIPMENT.— Check for safety equipment, such as the following:

- Spare electrical fuses (unless the vehicle has circuit breakers)
- Three red reflective triangles
- A properly charged and rated fire extinguisher
- Tire changing equipment (obtain from collateral equipage)
- Accident reporting package

Brake Test

If your vehicle is equipped with hydraulic brakes, perform the following test to check the brake system. Pump the brakes three times, then apply firm pressure to the pedal and hold for 5 seconds. The pedal should not move. If it does, there may be a leak or other problems.

To test the parking brake, you should allow the vehicle to move forward slowly and then apply the parking brake.

To test the service braking action, you should proceed at about 5 mph, then push the brake pedal firmly. A pull of the vehicle to one side or the other or any delay in stopping action is an indication of brake trouble. Any brake problems that occurred during this testing must be documented and repaired before operating the piece of equipment.

AIR BRAKES

Air brakes use compressed air to make the brakes work. They provide a safe way to stop large vehicles when maintained and used correctly. The air brake system is composed of three combined braking systems: the service brake system, the parking brake system, and the emergency brake system.

The service brake system applies and releases the brakes when you use the brake pedal during normal driving. The parking brake system applies and releases the parking brakes when you use the parking brake control. The emergency brake system uses parts of the service and parking brake system to stop the vehicle in the event of a brake system failure.

NOTE: The components of the air brake system are covered in chapter 3.

Brake Drums, Shoes, and Linings

Brake drums are located on each end of the axles. The wheels are bolted to the drums, and the braking mechanisms are located inside the drum. The brake shoes and linings are pushed against the inside of the drum, and this action causes friction that slows the vehicle and brings it to a stop. This friction creates heat and the heat a drum can take without damage depends on how hard and how long the brakes are used. Too much heat can stop the brakes from working properly.

S-CAM AIR BRAKES.— When the air brake pedal is pushed, air is let into each brake chamber (fig. 7-10). Air pressure pushes the rod out, moving the slack adjuster, thus twisting the brake camshaft. This action turns the S-cam that forces the brake shoes away from one another and presses them against the inside of the brake drum. When the brake pedal is released, the S-cam rotates back and a spring pulls the brake shoes away from the drum, allowing the wheels to roll freely.

WEDGE BRAKES.— On wedge brakes, the brake chamber pushrod pushes a wedge directly between the ends of two brake shoes. The wedge shoves the shoes apart and against the inside of the brake drum. Wedge brakes have either a single-brake chamber or two brake chambers that push wedges into both ends of the brake shoes.

DISC BRAKES.— The air pressure in air-operated disc brakes acts on a brake chamber that produces movement of the slack adjuster, like on the S-cam brake. But instead of the S-cam, a “power screw” is used. The pressure of the brake chamber on the slack adjuster turns the power screw. The power screw clamps the disc or rotor between the brake lining pads of a caliper.

NOTE: Wedge and disc air brakes are less common than the S-cam brake.

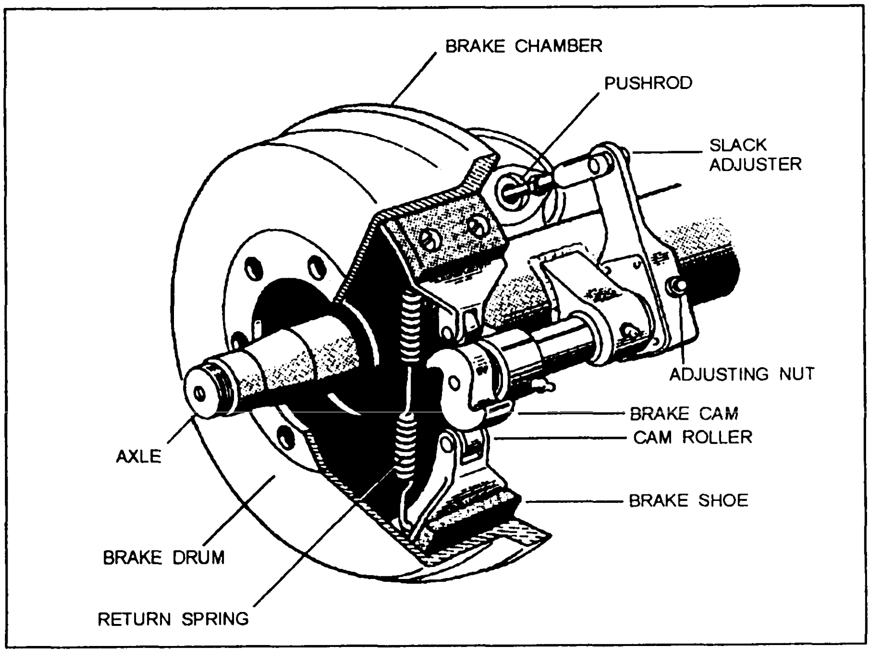


Figure 7-10.—S-cam air brake.

Spring Brakes

All trucks, tractor-trailers, and buses are equipped with emergency and parking brakes. These brakes are applied by the mechanical force produced by a spring brake. When you are driving, the powerful springs are held back by air pressure. A leak in the air pressure system causes the springs to engage the brakes. Engaging the parking brake control on the dashboard releases the air holding back the springs. This action allows the springs to engage the brakes.

Tractor and straight truck spring brakes engage when the air pressure drops to a pressure ranging between 20 to 45 psi. Do not wait for the brakes to engage automatically. When the low air pressure warning light and buzzer activates, you should bring the vehicle to a safe stop immediately, while you can still control the brakes.

The braking power of the spring brakes depends on the adjustment of the brakes. If the brake adjustment is incorrect, the regular, emergency, and parking brakes cannot work correctly.

Parking Brake Controls

On newer vehicles, a diamond shaped, yellow, push-pull control knob is used to engage or disengage the parking brakes. When the knob is pulled out, the brakes are engaged. By pushing the knob in, you can release the brakes. On older vehicles, the parking brake may be controlled by a lever. You should engage the parking brake anytime the vehicle is parked.

Using Air Brakes

When using air brakes, you should push the brake pedal down and control the pressure so the vehicle comes to a smooth, safe stop. If your vehicle is equipped with a manual transmission, do not push the clutch in until the engine rpm is lowered to idle speed. When stopped, select a starting gear.

EMERGENCY STOPS.— When applying air brakes in an emergency stop, brake so you can steer and keep your vehicle in a straight line. Use methods of controlled or stab braking.

Controlled Braking.— Controlled braking is also called “squeeze” braking. Controlled braking is applying the brakes as hard as possible without locking the wheels. Do not turn the steering wheel while doing this. If steering is required or the wheels begin to slide, release the brakes. Brake again as soon as the tires gain traction.

Stab Braking.—The stab braking method requires applying the brakes as hard as possible and releasing them when the wheels lock up. As soon as the wheels start to roll, apply the brakes fully again. It can take up to 1 second for the wheels to start rolling after releasing the brakes. You should stay off the brakes long enough to get the wheels rolling again; otherwise, the vehicle may not stay in a straight line.

DOWNHILL BRAKING.— The correct method for going down long grades is to use a low gear and travel at a slow speed that allows a fairly light, steady use of the brakes to prevent the vehicle from speeding up. When you go slow and apply light pressure, the brakes cool down and work properly.

CAUTION

When going down a hill, overuse of the brakes can make them get too hot which causes the brakes to fade. This can cause the operator to press down harder on the pedal to gain the required braking power. Prolonged action like this can cause the brakes to fade until they stop working.

Trailer Hand Valve

The trailer hand valve (also called the trolley valve) controls the trailer brakes. Do not use it when driving because of the danger of making the trailer skid. The foot brake sends air to all of the brakes on the vehicle, including the trailer. There is much less danger of causing a skid or jackknife when only the foot brake is used.

Tractor Protection Valve

The tractor protection valve keeps air in the tractor or truck should the trailer break away or develop a bad air leak. The valve is controlled by the **trailer air supply** control valve in the cab of the tractor or truck. The control valve allows the opening and shutting of the tractor protection valve. The tractor protection valve closes automatically when the air pressure drops to a range of 20 to 45 psi. When the tractor protection valve closes, it stops any air from escaping from the tractor. It also shuts off the air from the trailer emergency line, causing the trailer emergency brakes to engage.

Trailer Air Lines

Every combination vehicle has two air lines. These lines are the service line and the emergency line. They run between each vehicle, such as tractor to trailer, trailer to dolly, and dolly to second trailer.

SERVICE AIR LINES.— The service line carries air that is controlled by the foot brake or the trailer hand brake. Depending on how hard the foot brake is engaged, the pressure in the service line will similarly change. The service line is connected to relay valve(s) on the trailer to apply more or less pressure to the trailer brakes. As pressure increases in the service line, the relay valve opens and sends air pressure from the trailer air tanks to the trailer brake chambers, thus applying the trailer brakes.

EMERGENCY AIR LINES.— The emergency line has two purposes. First, it supplies air to the trailer air tanks. Second, the emergency line controls the emergency brakes on the combination vehicle. Loss of air pressure in the emergency line causes the trailer emergency brakes to activate. The pressure loss could be caused by a trailer breaking loose and tearing apart the emergency air hose. The loss could also be the result of a hose, metal tubing, or other parts breaking and causing an air leak. When the emergency line loses pressure, it also causes the tractor protection valve to close, causing the air supply knob to pop out.

Emergency lines such as hoses couplers, and other parts, have a red covering. The red covering allows you to separate the emergency lines from the service lines which have a blue covering.

Hose Couplers

Hose couplers, commonly known as **glad hands** (fig. 7-11), are coupling devices used to connect the service and emergency air lines from the truck or tractor to the trailer. The glad hands have rubber seals, known as rubber grommets, that prevent the air from escaping. Clean the rubber grommets before you connect the glad hands. When connecting the glad hands, press the two seals together with the glad hands at a 90-degree angle to each other. A turn of the glad hands attached to the hose joins and locks the couplers.

Some vehicles have “dead end” or dummy glad hands to which the hoses should be connected when not in use. This prevents water and dirt from getting into the glad hands and the air lines. This is very important because keeping the air system clean is a critical factor.

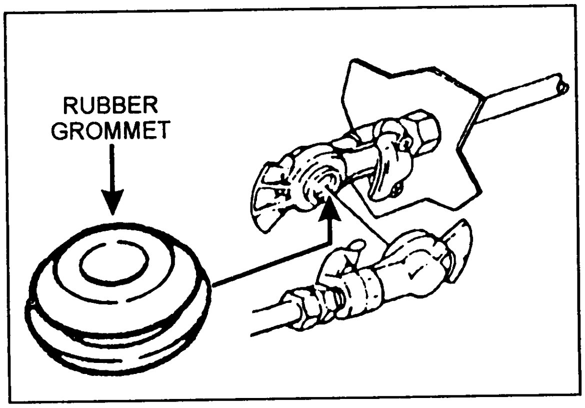


Figure 7-11.—Glad hands.

When connecting the glad hands, ensure the proper glad hands are coupled together. On some equipment, metal tags are attached to the lines with the words **service** and **emergency** stamped on them. The color blue is used for the **service line** and the color **red** for the **emergency** line connections.

If the air lines are crossed, supply air is sent to the service line instead of going to charge the trailer air tanks; therefore, air is not available to release the trailer spring brakes (parking brakes). If the spring brakes do not release when you push the trailer air supply control knob, check the air line connections.

CAUTION

Older trailers do not have spring brakes. If the air supply in the trailer air tanks has leaked out, emergency brakes will not exist, and the trailer wheels will turn freely. If you cross the air lines, the trailer will roll; however, there will be no trailer brakes.

NOTE: Always test the trailer brakes before driving by engaging the hand valve or by pulling the tractor protection valve. Once these brakes are engaged, shift the tractor to low gear and pull **gently** against the brake system to make sure the brakes work.

Shutoff Valves

Shutoff valves, commonly known as cutoff cocks, are used in the service and emergency lines glad hands located on the back of military series tractors, cargo

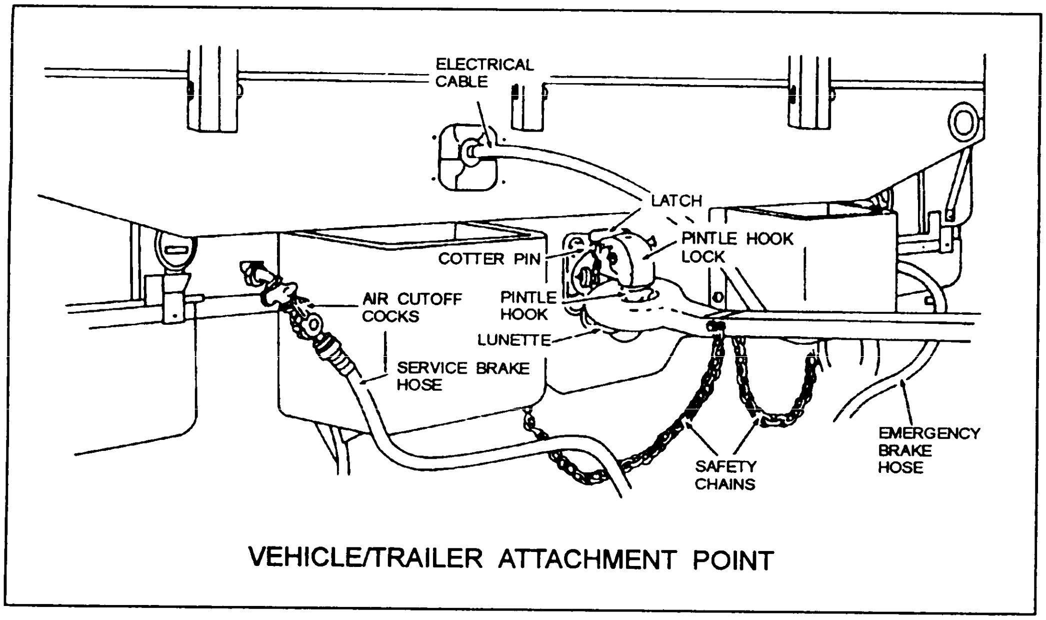

ELECTRICAL CABLE
LATCH
PINTLE HOOK LOCK
COTTER PIN
AIR CUTOFF COCKS
PINTLE HOOK
LUNETTE
SERVICE BRAKE HOSE
EMERGENCY BRAKE HOSE
SAFETY CHAINS
VEHICLE/TRAILER ATTACHMENT POINT

Figure 7-12.—Vehicle trailer hookup with glad hand cutoff cock.

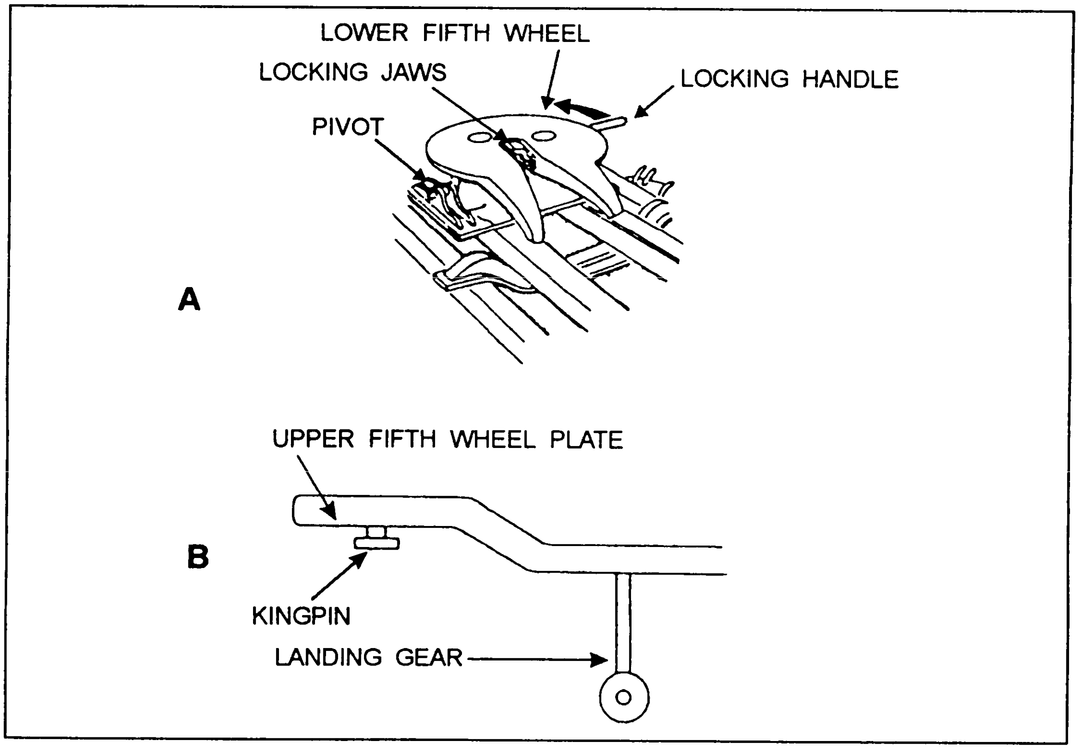

LOWER FIFTH WHEEL
LOCKING JAWS
LOCKING HANDLE
PIVOT
A
UPPER FIFTH WHEEL PLATE
B
KINGPIN
LANDING GEAR

Figure 7-13.—Fifth wheel assembly.

trucks, and trailers (fig. 7-12). These valves permit the opening and closing of the airlines when towing trailers.

Trailer Air Tanks

Trailers and dollies have one or more air tanks. The air tanks are filled by the **emergency air line** from the tractor. They provide the air pressure used to operate the trailer brakes by sending air pressure from the air tanks to the brakes via relay valves. The pressure in the **service line** signals how much pressure the relay valves should send to the trailer brakes. The pressure in the service line is controlled by the brake pedal and/or the trailer hand brake.

CAUTION

Do not allow water and oil to build up in the air tanks. Excessive amounts of water and oil affect the operation of the brakes negatively. Each tank has drain valve that should be drained daily.

OPERATION

In the NCF, tractor-trailer operations are managed by the transportation supervisor. The operation of a tractor-trailer is much more difficult than that for most other vehicles; therefore, operators must be mature, reliable, and experienced.

To drive a tractor-trailer safely, you must be able to control its speed and direction. Safe operation of a tractor-trailer requires skill in coupling and uncoupling, accelerating, steering, shifting gears, and braking. Additionally, you must remember to make allowances for the added length when turning, backing, and passing other vehicles and for maneuvering into position for loading and unloading.

Fifth Wheel Assembly

A tractor and trailer are separate units joined together by a fifth wheel. The fifth wheel consists of two metal plates: one on the tractor, known as the **lower fifth wheel** (fig. 7-13, view A), and one on the trailer, known as the **upper fifth wheel** (fig. 7-13, view B).

The upper and lower fifth wheel form a flexible coupling that permits both rotational and vertical movement between the tractor and trailer. The upper fifth wheel has a **kingpin** and the lower fifth wheel has **locking jaws** that lock around the kingpin to couple the tractor-trailer together. The locking jaws is operated by a hand lever that extends to the side of the lower fifth wheel and can be released by either pulling the locking handle forward, as shown in figure 7-13, or pulling the locking handle outward, as shown in figure 7-14.

When the trailer is not connected to the tractor, the front end of the trailer is supported by a retractable two-legged landing gear. The landing gear may be equipped with either wheels or pads (flat pieces of heavy metal). The glad hand connections for the service and emergency air lines and the electrical connection for the clearance, side marker, and brake lights are located on

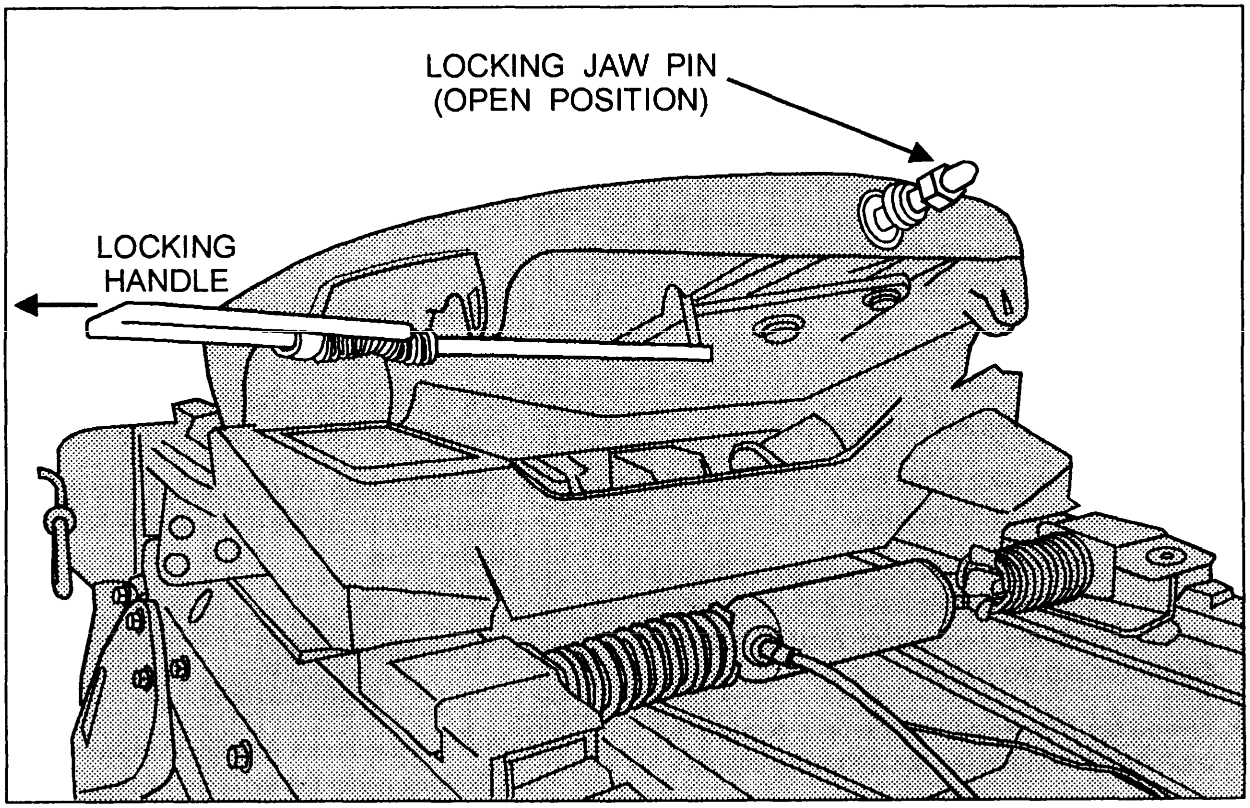


Figure 7-14.—Fifth wheel locking jaws in open position.

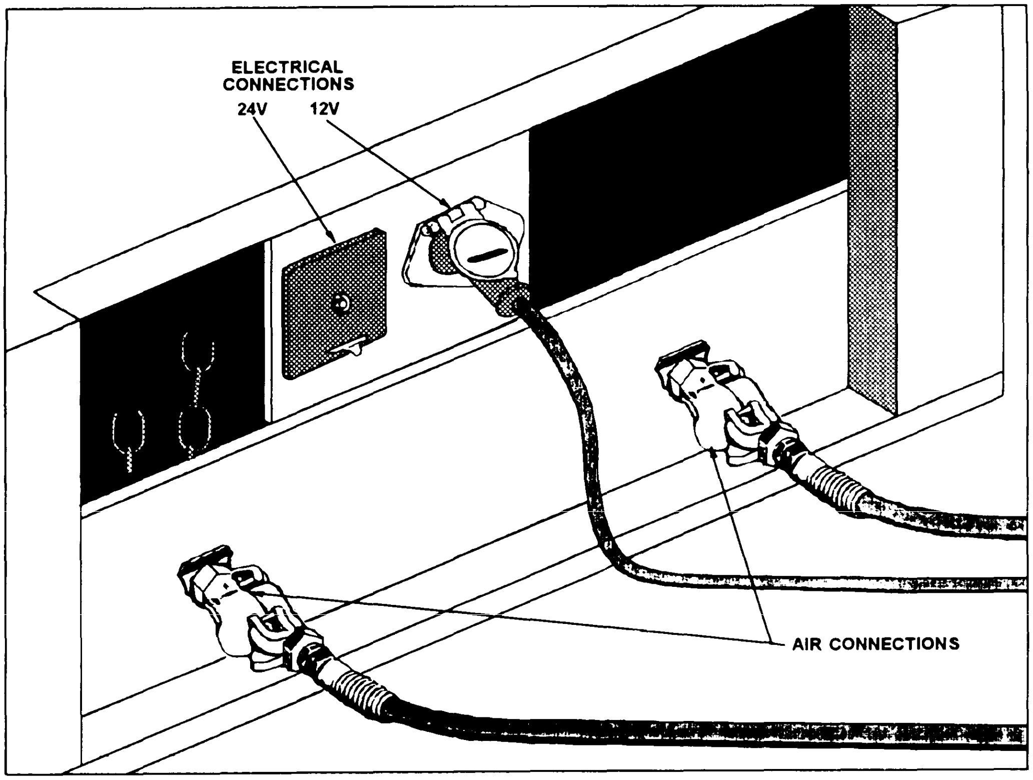


Figure 7-15.—Air and electrical connections.

the front of the trailer (fig. 7-15). Trailers in the NCF normally have two electrical connections adaptable for either a 12- or 24-volt electrical system.

Coupling and Uncoupling

Coupling and uncoupling correctly is basic to the safe operation of tractor-trailers. Incorrect coupling and uncoupling can be dangerous and cause unnecessary equipment damage and downtime. The basic steps for coupling a tractor to a trailer are as follows:

Step 1. Inspect fifth wheel

- Check for damaged and missing parts.
- Ensure the mounting to the tractor is secure and there are no cracks in the frame.
- Ensure the fifth wheel plate is greased. Failure to keep the fifth wheel plate lubricated could cause steering problems because of friction between the tractor and the trailer.
- Ensure the fifth wheel is in proper position for coupling by completing the following checks:
  1. Ensure the wheel is tilted down towards the rear of the tractor.
  2. Ensure the locking jaws are open.
  3. If equipped with a sliding fifth wheel assembly, ensure it is locked in position.
  4. Ensure the trailer kingpin is not bent or broken.

Step 2. Inspect area and chock wheels

- Ensure the area around the tractor and trailer are clear of obstacles.
- Check the trailer wheels and ensure chocks are in place and the spring brakes are engaged.
- Check all cargo (if any) and ensure it is secured from movement due to the tractor being coupled to the trailer.

Step 3. Position tractor

Position the tractor directly in front of the trailer. (Backing under the trailer at an angle could push the trailer sideways and bend or break the landing gear.)

- Check the position of the tractor by using both outside mirrors and by looking down both sides of the trailer.

Step 4. Back slowly

- Back slowly until the fifth wheel just touches the trailer.

Step 5. Secure tractor

- Apply the parking brake.
- Place the manual transmission in neutral; if an automatic transmission, place in park.
- Place wheel chocks.

Step 6. Check height of trailer

- The trailer should be low enough to allow it to be raised slightly by the tractor when the tractor is backed under it. Raise or lower the trailer as needed.

CAUTION

If the trailer is too low, the tractor may strike and cause unnecessary damage to both the rear of the tractor and the nose of the trailer. If the trailer is too high, it may not couple correctly.

- Ensure the kingpin and fifth wheel are aligned.

Step 7. Connect air lines to trailer

- Inspect rubber grommets in the glad hands for wear and tear.
- Connect the tractor emergency air line to the trailer emergency glad hands.
- Connect the tractor service air line to the trailer service glad hands.
- Ensure air lines are safely supported so they cannot be crushed or caught while the tractor is backing under the trailer.

Step 8. Supply air to trailer

- From the cab, push in the “air supply” knob to supply air to the trailer brake system. Military tractors are sometimes equipped with shutoff valves that must be opened to supply air to the trailer brake system.
- Check the air pressure gauge and wait until the air pressure is normal.
- Apply and release trailer brakes, listen for the sound of the trailer brakes being applied and released. You should hear the brakes move when applied and air escape when the brakes are released.
- Check the air pressure gauge for signs of major air loss.

Step 9. Lock trailer brakes

- Pull out the “air supply” knob or apply the trailer hand valve on the steering column to lock the trailer brakes.

Step 10. Back under the trailer

- Use the lowest reverse gear.
- Back the tractor under the trailer until the kingpin is locked into the fifth wheel.
- Pull the tractor gently forward while the trailer brakes are still engaged ensuring the trailer kingpin is locked into the locking jaws of the fifth wheel.

Step 11. Inspect coupling

- Place the transmission in neutral, if manual; in park, if an automatic transmission.
- Engage parking brakes.
- Disengage the trailer hand valve.

NOTE: Depending on your location, you may want to shut off the engine and take the key with you to prevent someone from moving the truck while you are under it.

- Inspect the area around the fifth wheel. Make sure there is no gap between the upper and lower fifth wheel. If there is a gap, something is wrong. The kingpin may be on top of the closed locking jaws; if so, the trailer can come loose easily.

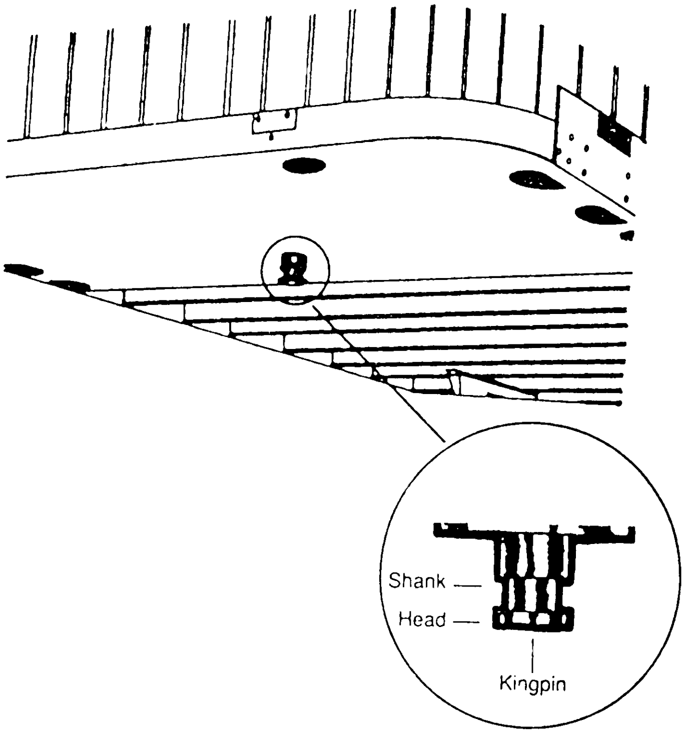


Figure 7-16.—Trailer kingpin.

- Go under the trailer and look into the back of the fifth wheel. Ensure the fifth wheel locking jaws have closed around the shank of the kingpin (fig. 7-16).
- Check that the locking lever pin is in the "lock" position (fig. 7-17).
- Ensure the safety catch is in position over the locking lever pin (if so equipped).

Step 12. Connect the electrical cord and check air lines

- Plug the electrical cord into the trailer (fig. 7-18) and fasten the safety catch.
- Inspect both air lines and electrical lines for signs of damage.
- Ensure air and electrical lines do not contact any moving parts of the vehicle.

Step 13. Raise landing gear

- Use the low gear (if so equipped) to begin raising the landing gear. Once free of weight, switch to the high gear range.
- Raise the landing gear all the way up. Driving with the landing gear part way up is not a good practice because it may catch on railroad tracks or other obstacles.
- Secure the crank handle safely after the landing gear is raised.

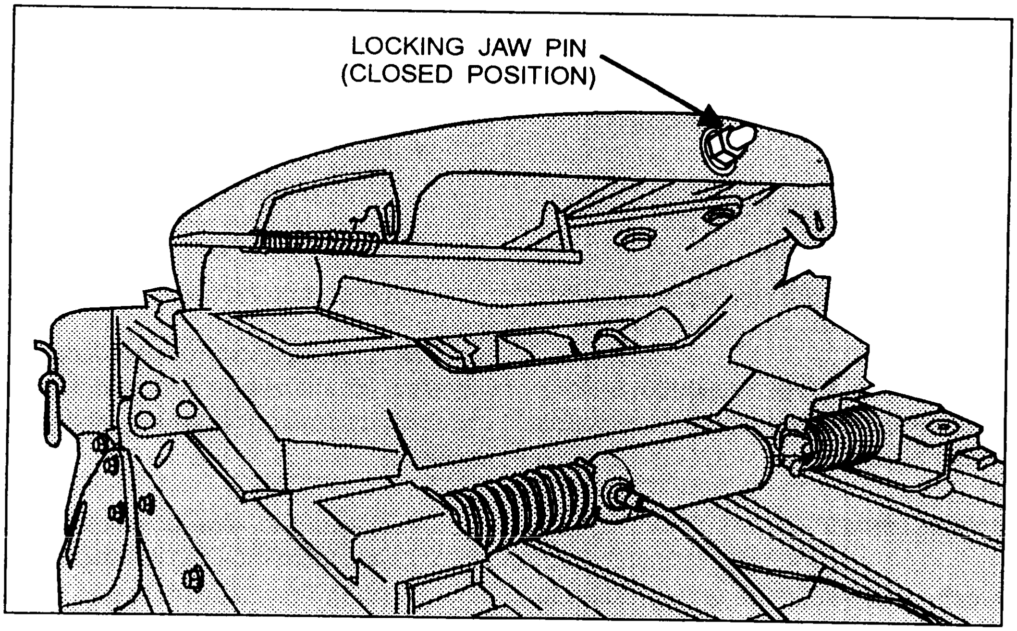


Figure 7-17.—Locked fifth wheel.

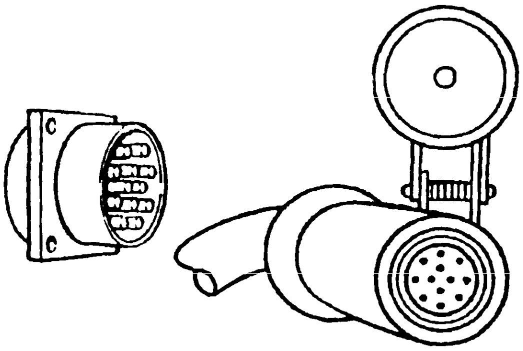


Figure 7-18.—Electrical connector.

- Check the rear of the tractor frame and the landing gear for enough clearance to make turns.
- Ensure there is enough clearance between the top of the tractor tires and the nose of the trailer.

Step 14. Remove trailer wheel chocks

- Remove and store wheel chocks in a safe place.

The basic steps for uncoupling a tractor from a trailer are as follows:

Step 1. Position tractor and trailer

- Ensure the parking area surface can support the weight of the trailer.
- Ensure the tractor is lined up with the trailer, if at all possible, because pulling out at an angle can bend and damage the landing gear.

Step 2. Ease pressure on locking jaws

- Shut off trailer air supply or engage the trailer hand valve to lock the trailer brakes.
- Ease pressure on the locking jaws by backing up gently. (This procedure helps you release the fifth wheel locking lever.)
- Apply the parking brakes while the tractor is backing; this holds the tractor in place with the pressure of the kingpin off the locking jaws.

Step 3. Lower the landing gear

- Chock the trailer wheels.
- If the trailer is empty: lower the landing gear until it makes firm contact with the ground.
- If the trailer is loaded: after the landing gear makes firm contact with the ground, turn the crank in low gear a few extra turns; this lifts some weight off the tractor suspension.

NOTE: Do not lower the landing gear so low that it lifts the trailer off the fifth wheel because doing this makes it harder to couple and uncouple.

Step 4. Disconnect electrical cable

- Disconnect the electrical cable and hang the cable with the plug down to prevent moisture from entering it.
- Ensure the electrical cable is supported so it will not be damaged while driving the tractor.

Step 5. Unlock fifth wheel

- Raise the safety catch over the locking pin (if so equipped).
- Pull the release handle to the “open” position.

WARNING

Keep legs and feet clear of the rear of the tractor wheels to avoid injury should the tractor move.

Step 6. Pull tractor partially clear of trailer

- Pull tractor forward until the fifth wheel comes out from under the trailer.
- Stop with the tractor frame underneath the trailer. This prevents the trailer from falling to the ground if the landing gear should collapse or sink.

Step 7. Secure tractor

- Apply the parking brake.
- Disengage the trailer hand valve to release trailer brakes.
- Place the manual transmission in neutral; in park, if an automatic transmission.

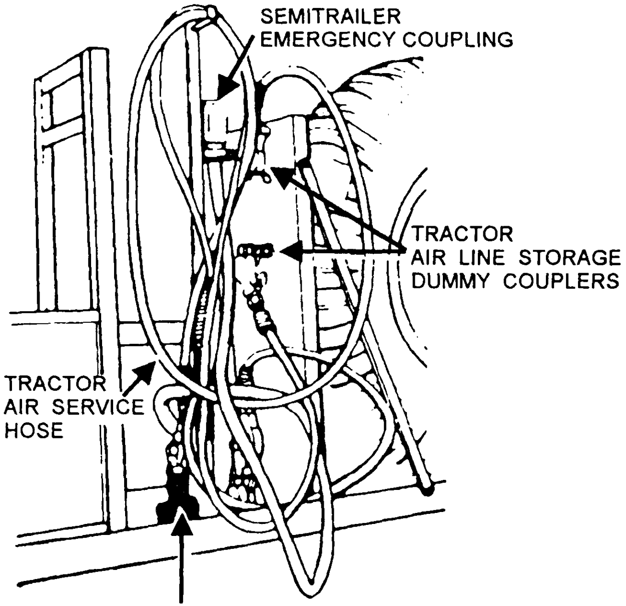

SEMITRAILER EMERGENCY COUPLING
TRACTOR AIR LINE STORAGE DUMMY COUPLERS
TRACTOR AIR SERVICE HOSE
TRACTOR AIR LINE CUTOFF COCKS

Figure 7-19.—Air line storage dummy couplers.

Step 8. Secure trailer

- Disconnect the air lines from the trailer. Connect the air line glad hands to dummy couplers at the back of the tractor cab (fig. 7-19).
- Ensure the lines are supported so they will not be damaged while driving the tractor.
- Ensure the ground is supporting the trailer.
- Ensure the landing gear is not damaged.

Step 9. Pull the tractor clear of trailer

- Release the parking brakes.
- Check the surrounding area and drive the tractor clear of the trailer.

Accelerating

When driving a tractor-trailer, you must not roll backward when you start, because you may hit a vehicle behind you. Partly engage the clutch before taking your right foot off the brake. If on an incline, engage the parking brake to hold the tractor, then release the parking brake only when you have applied enough engine rpm to keep from rolling backward. Another technique is to engage the engine hand throttle to increase the engine rpm while your right foot is on the brake and your left foot is partly engaging the clutch. As the clutch engages, release the foot brake, and disengage the engine hand throttle.

Accelerate smoothly and gradually so the tractor does not jerk. Rough acceleration causes unnecessary premature mechanical damage to the drive train and to the coupling. When traction is poor as in rain or snow, speed up gradually. Using too much power may cause the drive wheel to spin. If the drive wheels lose traction, do not apply the brakes; just take your foot off the accelerator pedal.

Steering

When steering, hold the steering wheel firmly with both hands on the opposite sides of the wheel. Should you hit a pothole or a curb, the steering wheel could pull away from your hands if you do not have a firm hold.

Shifting Gears

Correct shifting of gears is important. Not only must you have full control of your tractor-trailer, but "grinding to find them," a term used when a driver forces the gears to engage, clutch slipping, rapid engagement during shifting, improper downshifting, and so forth, causes premature failure of drive-line components.

Most tractor-trailers with manual transmissions require double clutching to change gears. The procedures for double clutching were covered in chapter 2. Remember: Shifting gears using double clutching requires practice. If you remain too long in neutral, you may have difficulty putting the transmission into the next gear. If this happens, do not try to force it. Instead, return to neutral, release the clutch, increase engine speed to match the road speed, and try to shift into the correct gear.

You can use two factors to tell when to shift the transmission. One is the engine rpm. The operator's manual tells you the operating rpm range for the tractor. Using the tachometer, shift up when the engine reaches the top of the range. The second factor is the road speed (mph). Through experience you will learn what speeds each gear is good for. Then by using the speedometer or engine sound, you will know when to shift.

MULTI-SPEED REAR AXLES AND AUXILIARY TRANSMISSIONS.— Multi-speed rear axles and auxiliary transmissions are used on many tractors to provide extra gears. These gears are shifted by a selector knob or switch on the gearshift lever of the main transmission. Many different transmission shifting patterns are used; therefore, it is **important** that the operator study the operator's manual before operating a tractor with an unfamiliar transmission shifting pattern.

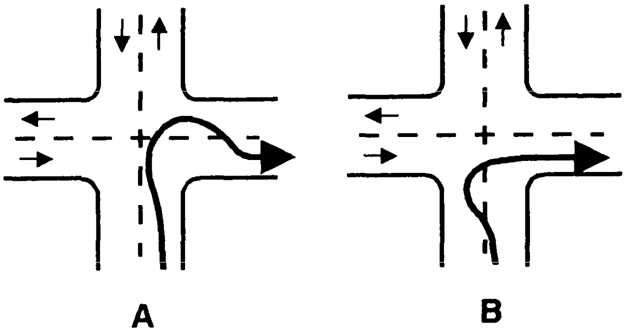


Figure 7-20.—Right turn.

AUTOMATIC TRANSMISSIONS.— Some tractors in the NCF are equipped with automatic transmissions. A low range can be selected to have a greater engine braking power when going down grades. The lower ranges prevent the transmission from shifting up beyond the selected gears. Shifting an automatic transmission incorrectly can cause serious damage to the transmission; therefore, operators must study the operator's manual for techniques of shifting automatic transmission.

RETARDERS.— Some tractors are equipped with a retarder that helps slow a vehicle, reducing the need for using the brakes. One common retarder is known as the "jake brake." Retarders reduce brake wear and provide another means to slow down. Retarders are controlled by the operator and are either exhaust, engine, hydraulic, or electric.

Turns

When making turns with the tractor-trailer, you must allow for the overall length of the unit. Remember: The tractor-trailer is hinged in the middle, and the trailer has a tendency to cut the corners, rather than follow the tractor. For this reason, it is necessary to make a wider turn than when turning with a straight truck.

CAUTION

Turning turn signals on well in advance of starting the turn is extremely important. This action warns other drivers that a turn is going to be made and allows them to drive safely.

RIGHT TURNS.— When performing a right-hand turn, turn slowly to give yourself and others time to avoid problems. If you cannot make the right turn without swinging into another lane, turn wide as you complete the turn, as shown in figure 7-20, view A. Keep the rear of the tractor-trailer close to the curb to stop any drivers from passing on the right. If you must cross into the oncoming traffic lane when making your turn, watch for vehicles coming towards you. Give them room to go by or stop; however, do not back up for them, because you may have a vehicle directly behind you.

Do not turn wide to the left as you start the turn to the right, as shown in figure 7-20, view B, because a following driver may think you are turning left and try to pass you on the right. Remember: If you turn too sharp while making a right turn, your trailer will ride up the curb and possibly run over obstructions (fig. 7-21).

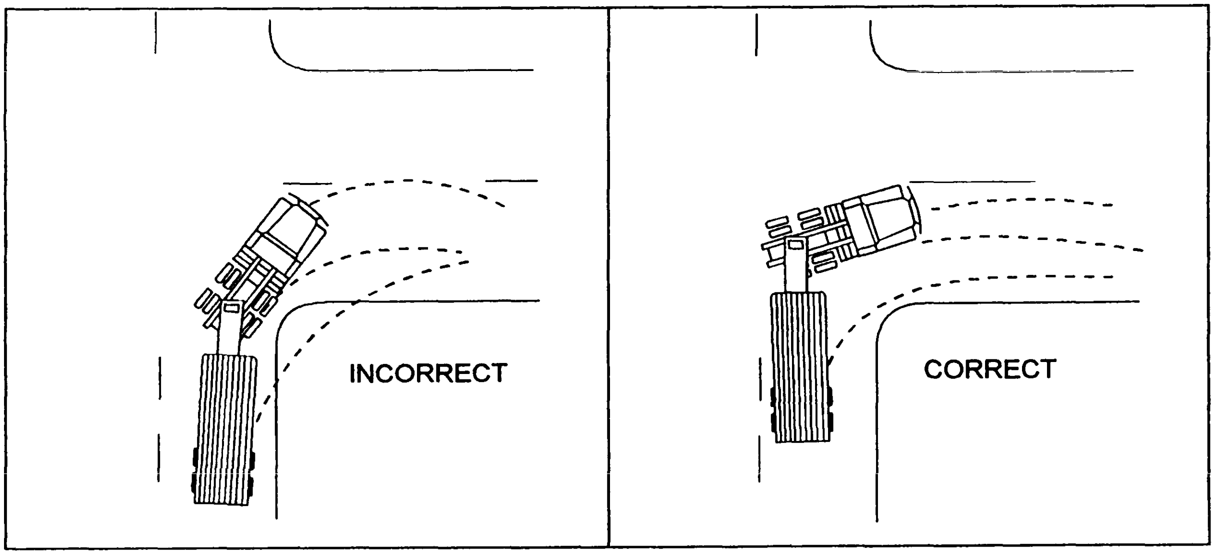


Figure 7-21.—Incorrect right turn.

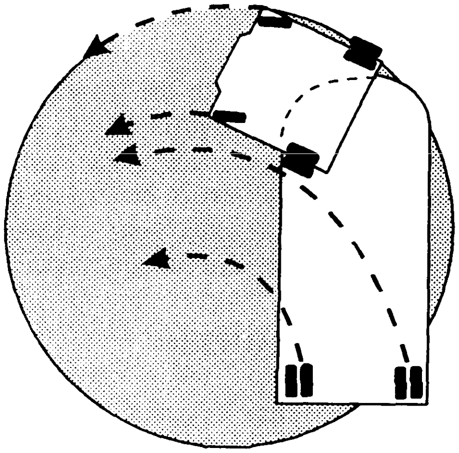


Figure 7-22.—Tractor-trailer left turn off tracking.

LEFT TURNS.— On a left turn, ensure you have reached the center of the intersection before you start the left turn. If you turn too soon, the left side of your vehicle may hit another vehicle because of off tracking (fig. 7-22).

If there are two turning lanes, always take the right-hand turn lane, as shown in figure 7-23. Do not start in the inside lane because you may have to swing right to make the left turn. You may not see vehicles on the right and cause a collision.

Backing

When backing a tractor-trailer, reverse the procedure you would use to back a bus or a straight truck; for example, if you want the trailer to go to the left, turn the steering wheel to the right. After the trailer is headed in the desired direction, turn the steering wheel slowly to the left. This puts the tractor in the same line of travel as the trailer and prevents the tractor and trailer from jackknifing. (The term *jackknifing* means a condition where the tractor and trailer are jammed together at an acute angle.)

Backing the trailer to the left is known as **sight-side** backing because you have a better view of the area into which you are backing, as shown in figure 7-24, view A. Sight-side backing is the recommended method for backing.

Reverse the sight-side backing procedures to back a trailer to the right. This is known as **blind-side** backing and should be done only when it is absolutely necessary. As shown in figure 7-24, view B, as the driver, you cannot see the rear of your trailer or the area into which you are backing.

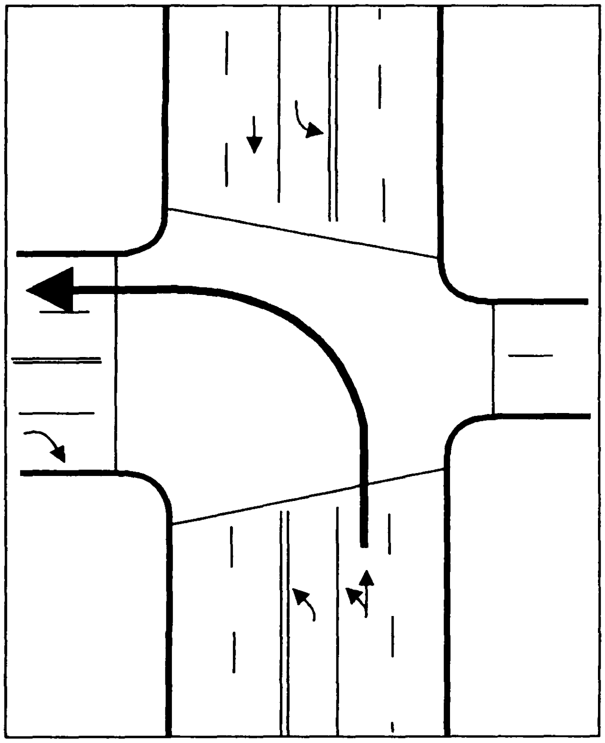


Figure 7-23.—Left turn from right-hand lane.

CAUTION

> You should always use a backing guide when performing backing operations with a tractor-trailer.

SAFETY

When pulled off the road with a tractor-trailer, turn on the four-way emergency flashers. However, do not trust taillights to provide a warning because drivers have crashed into the rear of parked vehicles because they thought it was moving. If you must stop on a road or on a shoulder, you should place reflective triangles within as soon as possible. The reflective triangles are placed at the following locations:

1. On a two lane or undivided highway, place reflective triangles on the traffic side of the vehicle within 10 feet of the front or rear corners. This marks the location of the vehicle. Additionally, place reflective triangles about 100 feet behind and ahead of the

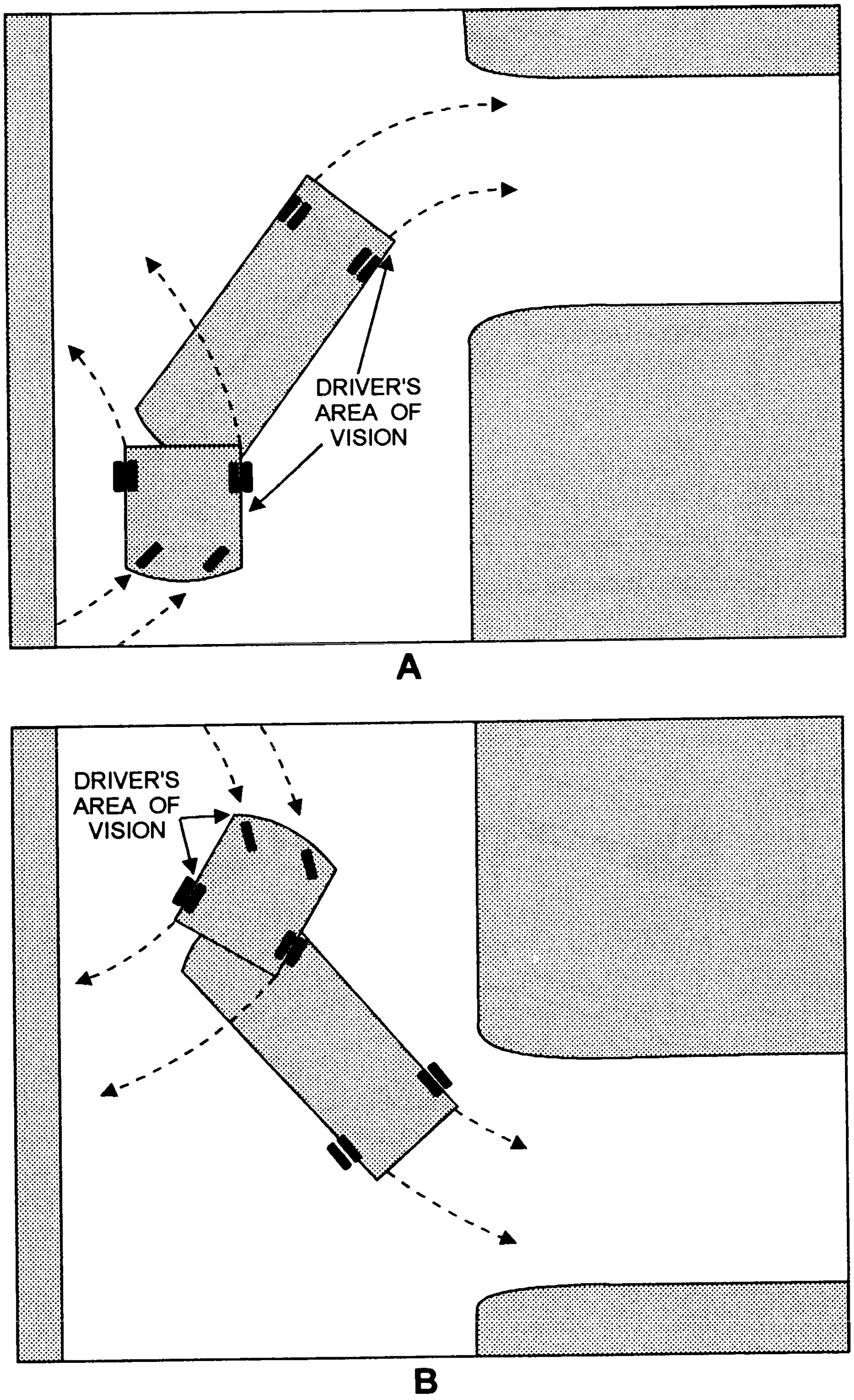

DRIVER'S
AREA OF
VISION
A
DRIVER'S
AREA OF
VISION
B

Figure 7-24.—Backing a tractor-trailer.

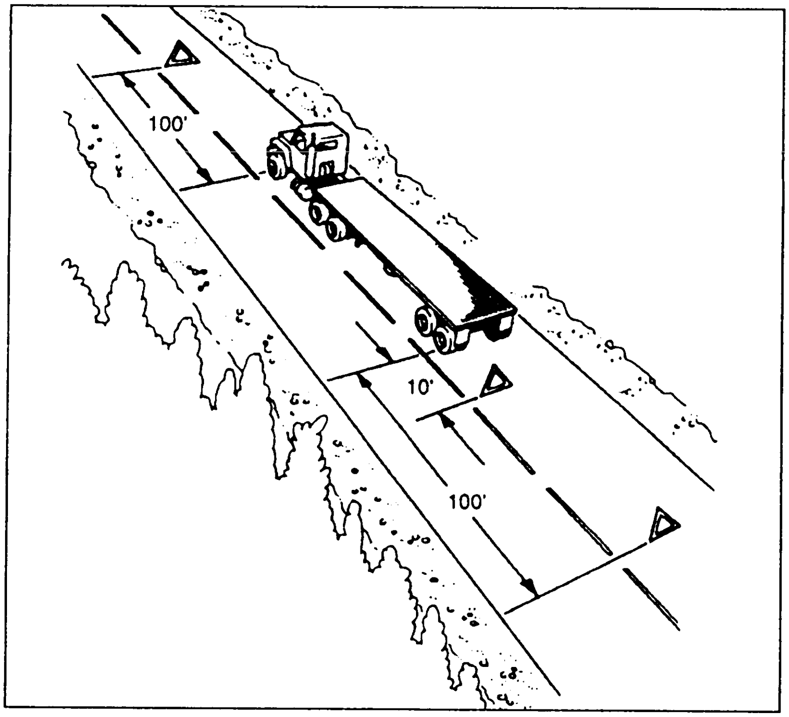


Figure 7-25.—Reflective triangle placement: two lane or undivided highway.

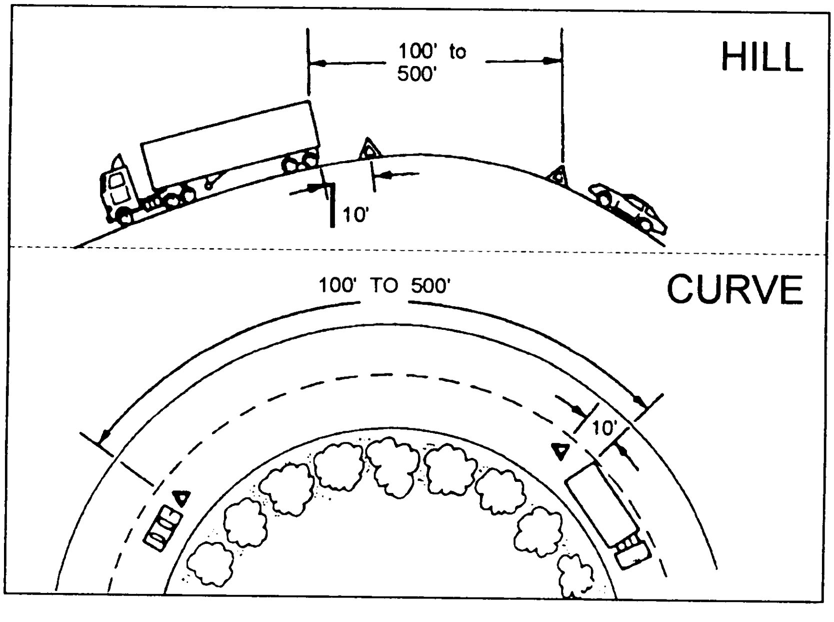


Figure 7-26.—Reflective triangle placement: obstructed view.

tractor-trailer on the shoulder or in the lane you are stopped in, as shown in figure 7-25.

2. If you are stopped beyond any hill, curve, or other obstruction that prevents other drivers from seeing the tractor-trailer within 500 feet, place reflective devices, as shown in figure 7-26.

3. If you are stopped on or by a one-way or divided highway, place reflective triangles 10 feet, 100 feet, and 200 feet toward the approaching traffic, as shown in figure 7-27.

When driving a tractor-trailer, you must maintain a safe following distance to avoid a rear-end collision. A

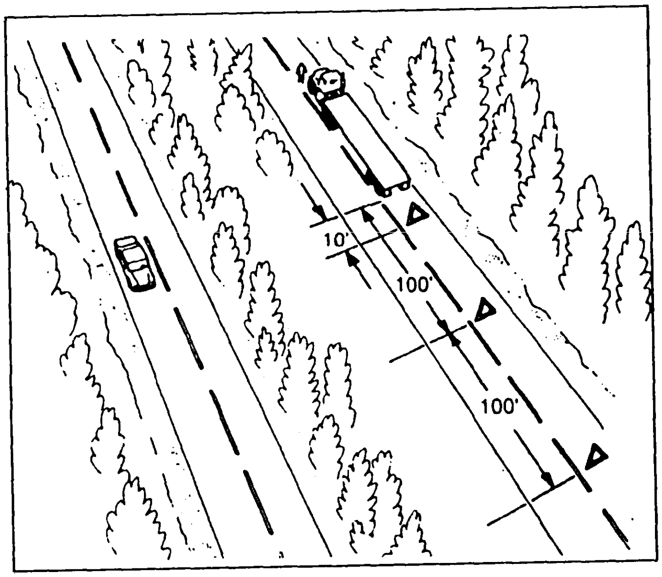


Figure 7-27.—Reflective triangle placement: one way or divided highway.

rule of thumb used for measuring how much distance you should maintain from the vehicle in front of you is at least 1 second for each 10 feet of vehicle length at speeds below 40 mph. At greater speeds, you must add 1 second for safety; for example, if you are operating a 40-foot vehicle, you should allow at least 4 seconds between you and the vehicle ahead. In a 60-foot tractor-trailer, you need 6 seconds. For over 40 mph, you need 5 seconds for a 40-foot vehicle and 7 seconds for a 60-foot tractor and trailer.

To measure distances, wait until the vehicle ahead passes a shadow on the road, a pavement marking, or some clear landmark. Then count off the seconds as "one thousand-and-one, one thousand-and-two" and so forth, until your vehicle reaches the same spot. Compare your count with the rule of 1 second for every 10 feet of length. If you are operating a 40-foot truck and only counted up to 2 seconds, you are too close.

LOADING AND SECURING CARGO

As a tractor-trailer operator, you must have an understanding of the basic procedures and safety rules used when transporting construction supplies and equipment. Improper loading of any load can be a danger to yourself and others around you, cause damage to the tractor-trailer, affect the steering of the tractor, and so forth. The **operator,** whether or not you loaded and secured the load yourself, is responsible to inspect the load, to recognize overloads and poorly balanced weight, and to ensure that the load is properly tied, strapped, or chained down, and covered (if required).

NOTE: It takes less time to tie down a load than it takes to report the reason a load fell off a trailer.

Vehicle Weight Definitions

The operator is responsible for knowing how much weight is loaded on the tractor-trailer and knowing the total weight of both the unit and cargo. The terms used for vehicle weight is as follows:

Payload allowance or payload is the maximum weight of material that can be transported.

Gross vehicle weight (GVW) is the total weight of a single vehicle plus its load.

Gross combination weight (GCW) is the total weight of a powered unit including the trailer(s) and cargo.

Gross vehicle weight rating (GVWR) is the maximum GVW specified by the manufacturer for a single vehicle, including the load.

Gross combination weight rating (GCWR)is the maximum GCW specified by the manufacturer for a specific combination of vehicles, including the load.

Curb weight is the total weight of the empty truck with the fuel tank, cooling system, and crankcase filled. Additionally, it also includes the weight of tools, spare tire, and all other equipment specified as standard. However, this weight does not include the weight of the payload and operator.

Axle weight is the weight transmitted to the ground by one axle or one set of axles.

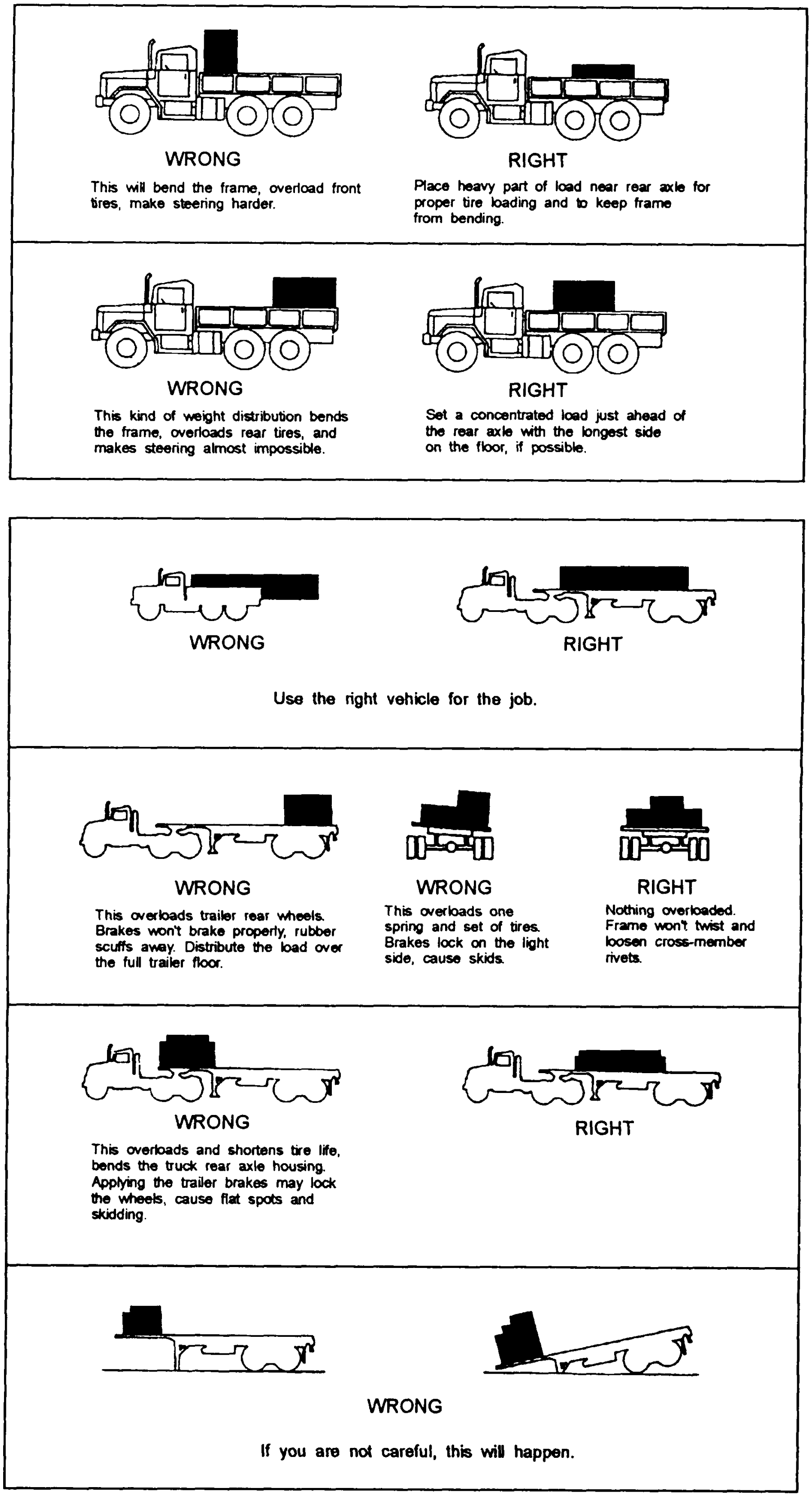
Tire load is the maximum safe weight a tire can carry at a specified pressure. This rating is stated on the side of each tire.

Suspension systems have a manufacturer's weight capacity rating.

Coupling device capacity are rated for the maximum weight they can pull and/or carry.

Operating Conditions

The maximum payload of a truck is determined by subtracting the curb weight and weight of the driver (175 pounds) from the manufacturer's gross vehicle weight rating. The maximum gross vehicle weight rating for a specified operating condition applies only when the tires and equipment on the truck are according



WRONG

This will bend the frame, overload front tires, make steering harder.

RIGHT

Place heavy part of load near rear axle for proper tire loading and to keep frame from bending.

WRONG

This kind of weight distribution bends the frame, overloads rear tires, and makes steering almost impossible.

RIGHT

Set a concentrated load just ahead of the rear axle with the longest side on the floor, if possible.

WRONG

RIGHT

Use the right vehicle for the job.

WRONG

This overloads trailer rear wheels. Brakes won't brake properly, rubber scuffs away. Distribute the load over the full trailer floor.

WRONG

This overloads one spring and set of tires. Brakes lock on the light side, cause skids.

RIGHT

Nothing overloaded. Frame won't twist and loosen cross-member rivets.

WRONG

This overloads and shortens tire life, bends the truck rear axle housing. Applying the trailer brakes may lock the wheels, cause flat spots and skidding.

RIGHT

WRONG

If you are not careful, this will happen.

Figure 7-28.—Correct placement of payload.

to the manufacturer's recommendations for the specified operating condition; that is, ideal, moderate, or severe.

IDEAL CONDITION.— An ideal condition is when a truck is operated over improved, level roads, such as asphalt or concrete, at constant, relatively moderate speeds with no adverse weather or road conditions. Under these conditions, recommended payload equals 100 percent of maximum permissible payload.

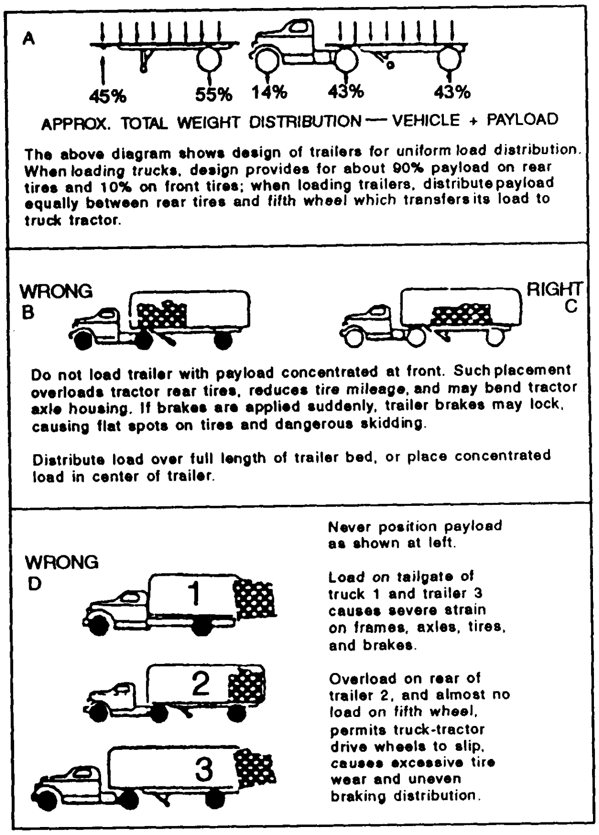
MODERATE CONDITION.— A moderate condition is when a truck is operated at high speeds over improved highways, such as asphalt or concrete, with or without long or steep grades. Moderate conditions also include operating at moderate speeds over semi-improved roads with gravel or equivalent surfacing, in gently rolling country with few steep grades and no adverse weather or road conditions. Under these conditions, recommended payload equals 80 percent of maximum permissible payload.

SEVERE CONDITION.— A severe condition is when the vehicle is operated off the highway on rough or hilly terrain or over unimproved or pioneer access roads with deep ruts, holes, or steep grades. These conditions also include operating where traffic has created deep holes or ruts in heavy snow, covering normally good city streets or highways. Under these conditions, the recommended payload equals 64 percent of the maximum permissible payload.

Weight Distribution

Distribution of cargo has a definite bearing on the life of tires, axles, frame, and other parts of the vehicle. The fact that a truck or trailer is not loaded beyond its gross vehicle weight capacity does not mean that the individual tires and axles may not be overloaded by faulty distribution of the cargo. Additionally, states have maximums for GVW, GCW, and axle weights. Axle weights prevent the overloading of bridges and roadways. Some examples of proper and improper placement of the load are shown in figure 7-28.

To load a truck or tractor-trailer properly, you have to determine the center of the payload. In a truck, the position of the center of the payload is the center of the body or the point midway between the rear of the driver's cab and the tailgate. In a tractor-trailer unit, the position of the center of the payload is roughly the center of the trailer body, because the front wheels of the tractor seldom carry any of the payload. When you are loading, ensure that the maximum capacity of the vehicle is not exceeded over any one axle and, if possible, that loads are distributed so there is less-than-maximum axle loading. Examples of approximate distribution of total weight are shown in figure 7-29.



The above diagram shows design of trailers for uniform load distribution. When loading trucks, design provides for about 90% payload on rear tires and 10% on front tires; when loading trailers, distribute payload equally between rear tires and fifth wheel which transfers its load to truck tractor.

Do not load trailer with payload concentrated at front. Such placement overloads tractor rear tires, reduces tire mileage, and may bend tractor axle housing. If brakes are applied suddenly, trailer brakes may lock, causing flat spots on tires and dangerous skidding.

Distribute load over full length of trailer bed, or place concentrated load in center of trailer.

Never position payload as shown at left.

Load on tailgate of truck 1 and trailer 3 causes severe strain on frames, axles, tires, and brakes.

Overload on rear of trailer 2, and almost no load on fifth wheel, permits truck-tractor drive wheels to slip, causes excessive tire wear and uneven braking distribution.

Figure 7-29.—Distribution of weight.

The payload weight must be distributed over the body properly so the percentage of weight carried by the front axle and that carried by the rear axle equals the ratio for which the vehicle was designed, as shown in figure 7-29.

Loading Cargo

The tractor-trailer can be adapted to transport various types of materials, such as fragile, bulky, compact, dense, rough and high center-of-gravity items. To accommodate a variety of items, you must plan the load, properly prepare the tractor-trailer, and secure the load to the vehicle. Securing the load by restraining it with proper lines, cargo straps, chains, or fastened by tie-downs or binders should keep it from shifting or falling off the vehicle. Should a load fall from a vehicle, it could foul underpasses, culverts, bridge abutments, and create a hazard to pedestrians. Protect fragile items

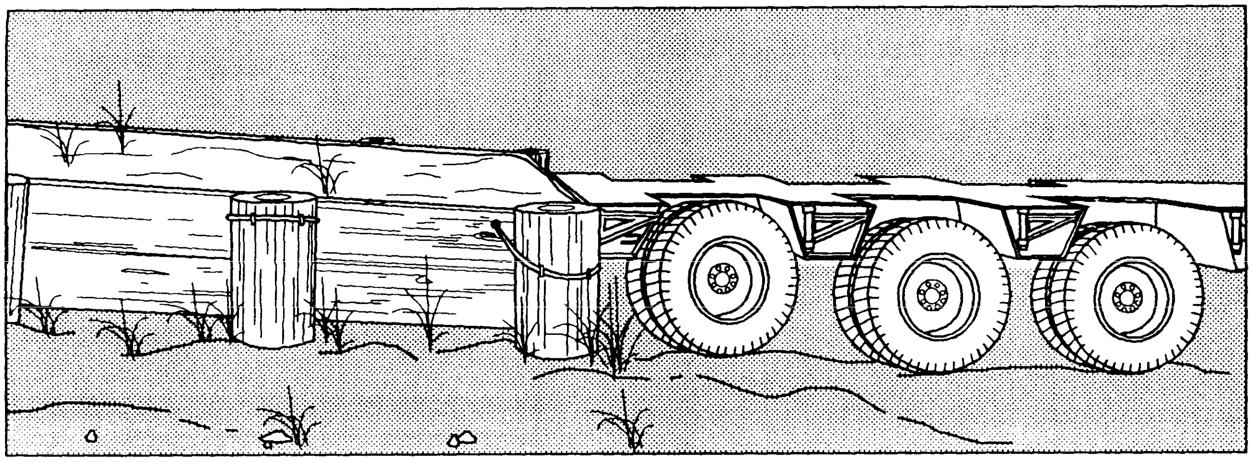


Figure 7-30.—Permanent loading ramp.

from damage by chafing (rubbing together) with cardboard, paper, cloth, or other filler.

Loading Equipment

Loading equipment onto a trailer is dangerous. In most cases the equipment will be just as wide as the trailer with a little room for error. Always use a guide to ensure that the equipment is on the trailer straight and that you do not run it off the trailer.

Regardless of what type of equipment you are loading or what type of trailer you are using, there are general rules that apply. The rules are as follows:

1. Have the equipment in line with the trailer and the transmission placed in low gear. Increase the throttle of the tractor just high enough to have power to pull itself onto the trailer.

2. Watch and follow your guide.

3. Do not steer sharply.

4. Do not stop except for an emergency.

5. For crawler machines only, move slowly at the top of any ramp or a jarring fall can result when the machine is past the balance point.

6. Center the equipment on the trailer to load the truck-tractor and trailer axles evenly.

LOW-BED TRAILER.— When loading a low-bed trailer with a self-propelled machine, you must use a ramp, blocks, bank or pile of dirt, or a ditch.

Portable ramps are heavy and hard to handle and require as many as four people to lift, carry, and set up. In most equipment yards, a permanent ramp is constructed of timber or concrete (fig. 7-30) to support the loading and unloading of equipment.

Blocks can be used to load crawler equipment but are not recommended for wheeled equipment. Use blocks if you have nothing else; however, be cautious because the machine will be at a greater angle than desired when the balance point is met (fig. 7-31.)

When a trailer can be backed against a bank or into a ditch, you may load or unload without the use of ramps.

When you have to load a machine and you do not have ramps, blocks, or ditches, you may have to push up a pile of dirt from which to load. Do not dig a hole in finish grade or any place you would have to smooth out. But, if you do push up a pile of dirt for a ramp, ensure the ramp angle is not too steep (3 feet out for every 1 foot up). Ensure the ramp is wider than the trailer and somewhat compacted to support the ground-bearing pressure of the equipment.

TILT-BED TRAILER.— A tilt-bed is like having portable ramps all the time. The bed will tilt (fig. 7-32) for the load to move up and forward of the balance point. As the load continues to move forward, the bed lowers into the transport position. Ensure the tilt-bed locking device and safety lock, as shown in figure 7-6, are opened before the bed is lowered.

WARNING

When using a tilt-bed trailer to haul equip ment, do not attempt to load or unload equipment from a ramp or dock as would be performed when using a low-bed trailer. This action is dangerous and causes severe damage to the tilt-bed trailer and the tilt-bed deck-locking mechanism.

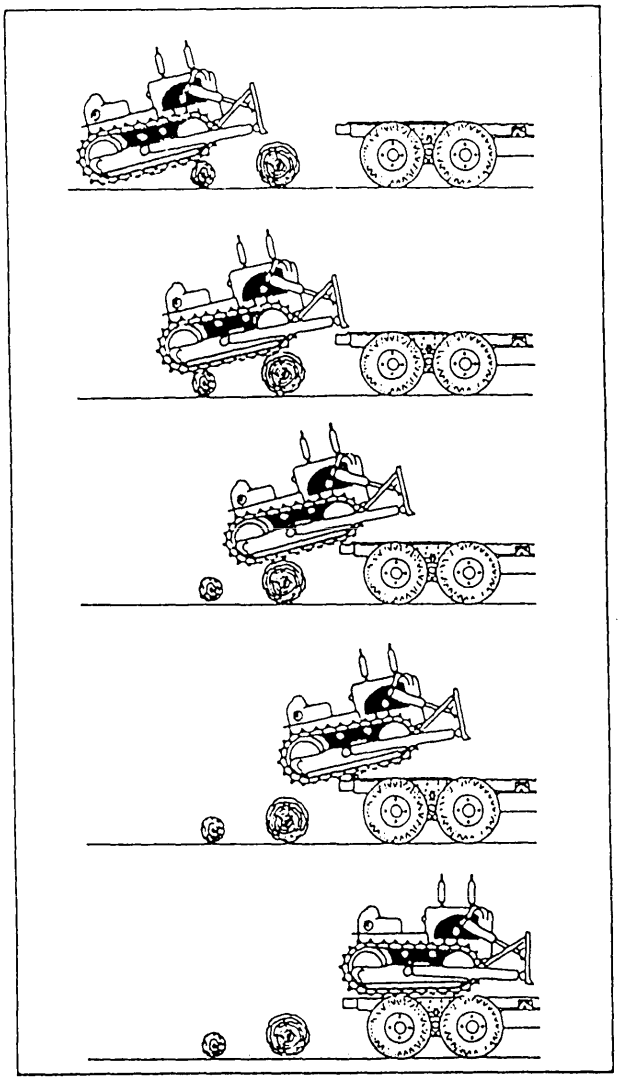


Figure 7-31.—Loading crawler equipment using blocks.

CAUTION

Using a tilt-bed trailer in damp or wet conditions is extremely dangerous and can cause uncontrollable sliding of equipment off the trailer during loading and unloading operations.

DETACHABLE GOOSENECK TRAILER.— Detachable gooseneck trailers are designed so when the gooseneck is detached you can load a machine from the front without any ramps or tilting of the deck at the balance point.

The gooseneck and frame are held together in alignment by removable pins or safety locks. Removing or releasing the pins or safety locks and disconnecting the brake and electrical lines, the two units are lowered to the ground by a hydraulic jack in the gooseneck or by a line from a winch mounted on the tractor. The gooseneck is then detached from the frame and carried or dragged a short distance by the tractor.

Ramps are flipped over to rest on the ground, and the equipment is driven up onto the trailer. The gooseneck is backed into place, attached, lifted, and locked. The brake and electrical line are reconnected, and the ramps are folded onto the deck of the trailer.

You can also load from the rear, like a regular low-bed trailer. Before you operate this type of trailer, read and understand the operator's manual. These trailers have low ground clearance, so take extreme care when crossing any high point in the roadway, such as railroad tracks, speed bumps, and dips.

Securing Cargo

Regardless of what type of truck you are operating, material you are hauling, or how far you are hauling it, your load must be secure from falling or shifting. When a load shifts, the weight of the load has moved also. This could cause an axle to be overloaded and mechanical failure to occur.

Certain conditions can cause cargo being transported to shift; however, almost all cargo movement can be controlled with the use of proper blocking and bracing. Blocking is used in the front, back, and/or sides of a piece of cargo to keep it from sliding. Blocking

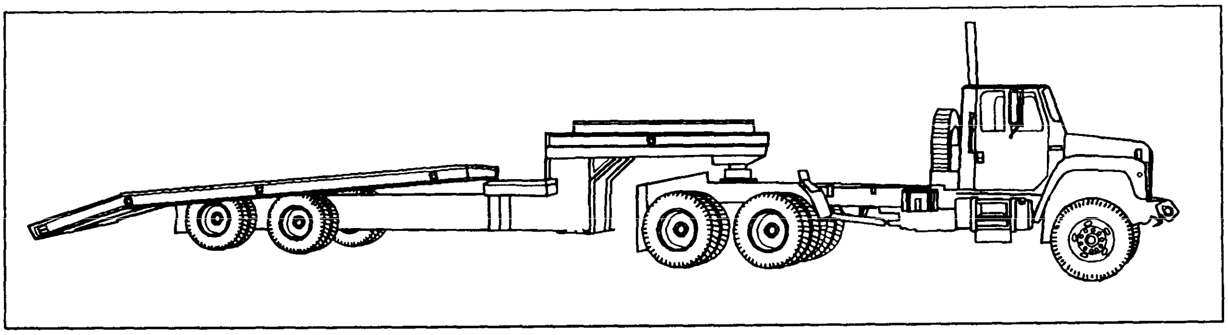
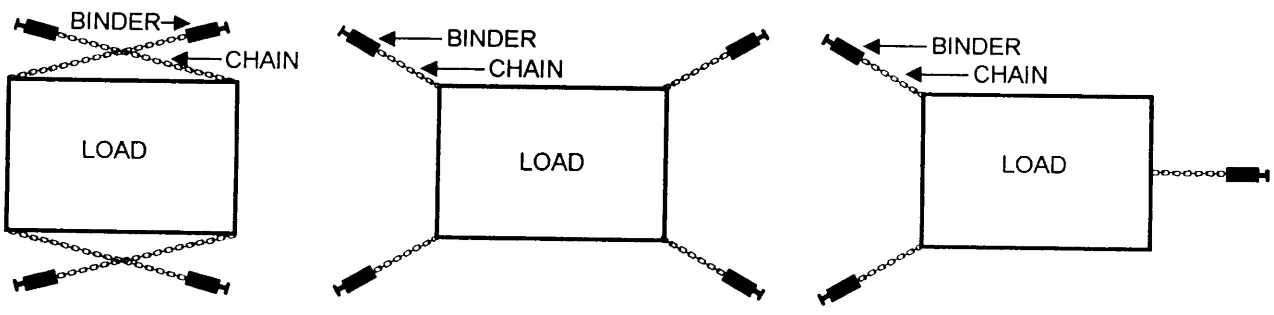


Figure 7-32.—Tilt-bed trailer with bed in the tilt position.



SYMMETRICAL

SYMMETRICAL

UNSYMMETRICAL

Figure 7-33.—Symmetrical tie-down pattern.

should be shaped to fit snugly against the cargo and should be secured to the deck of the trailer to prevent the cargo from moving. **Bracing** is also used to prevent movement of the cargo. Bracing is placed from the upper part of the cargo to the floor and/or walls of the cargo compartment.

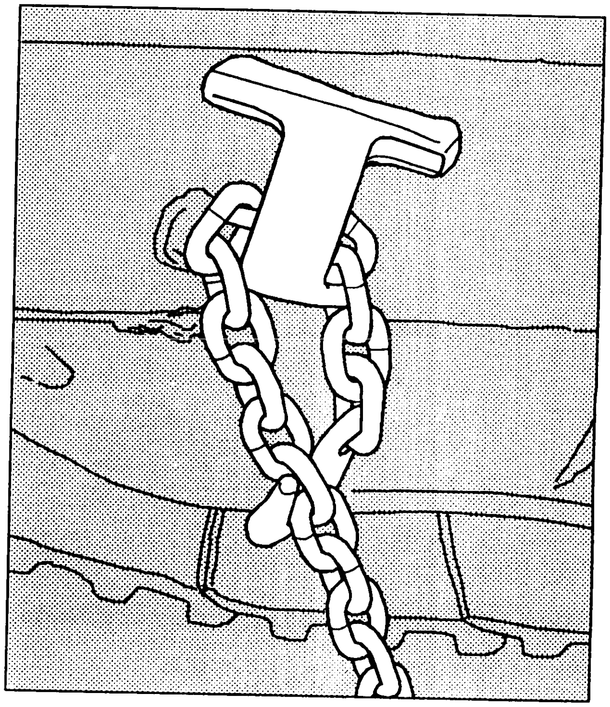
Because cargo loads have a tendency to shift, a common rule of thumb is to inspect the cargo and the securing devices before departing and within 25 miles after beginning a trip. Always check the cargo and securing devices as often as necessary during a trip to keep the load secured. Inspect the cargo and securing devices after you have driven for 3 hours or 150 miles and after every break taken during the trip.

LOOSE MATERIAL.— Dump trucks are often used to haul loose material. Soil, aggregate, and sand are examples of cargo that is categorized as loose material. When you are operating dump trucks, be sure that no part of the load can fall off your truck when making turns. You should stop loading before it reaches the top of the side or end gate. Dirt spilled in curves and turns creates driving hazards and should be cleaned up daily. Another hazard created by loose material is a broken windshield caused by aggregate falling from dump trucks.

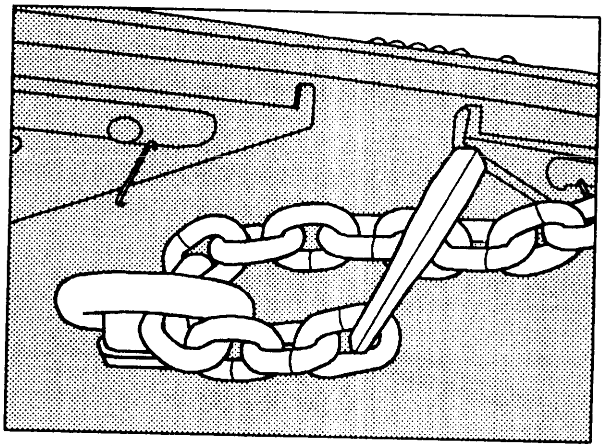
NOTE: In some states and on some deployment locations, it is a requirement that all loose material loads carried in dump trucks must be covered.

BUILDING MATERIAL.— When loading steel, lumber, or anything that must be unloaded with a forklift or crane, you should place 4 by 4 timbers or pallets under the load. This helps get forks or cables in and out from under the load

RESTRAINTS.— Loads must be secure enough to prevent movement in any direction, which means movement forward, aft, vertically, and horizontially.



CHAIN HOOKED TO EQUIPMENT



CHAIN HOOKED TO TRAILER

Figure 7-34.—Chains properly hooked on the equipment and trailer tie-down eyes.

When securing loads, place the tie-downs in a symmetrical pattern, as shown in figure 7-33.

A tie-down assembly must have a safe working load (SWL) of 1 1/2 times the weight of the load to be restrained. For example, to restrain a crawler tractor weighing 55,000 pounds, you need a tie-down assembly for 82,500 pounds (55,000 x 1.5 = 82,500). This means you need eight 1/2-inch chains with an SWL of 11,000 pounds each and eight binders with 1/2-inch hooks.

On flatbed or lowboy trailers without sides, cargo must be secured to the trailer to keep it from shifting and falling off. In closed van trailers, tie-downs can also prevent cargo from shifting that may affect the handling of the vehicle. Tie downs must be of the proper type and strength. The combined strength of all tie-downs must be strong enough to lift 1 1/2 times the weight of the piece of cargo tied down.

Chains.— Chains make up most of our tiedown assemblies. The size of chains normally used in the NCF is 3/8 and 1/2 inch. They are made of the class A type of alloy steel. Know the safe working load of any chain before you put it to use.

Chains used for restraints should have grab hooks on both ends. Attach the hook into the chain as close as possible to the tie-downs on the trailer and on the equipment (fig. 7-34). This prevents the chain from getting slack once the binder is attached and closed.

Binders.—Binders are chain-tightening devices that are made of steel with swivels, chain hooks, and a lever. You hook one of the binder hooks on the chain near the trailer deck and the other hook higher up the chain near the load. The chain is tightened by pulling the lever down, as shown in figure 7-35. A 3-inch-diameter 3-foot-length pipe, commonly known by the term **cheater bar,** is normally used on the lever to provide more leverage when closing the binder.

WARNING

> When you are closing and opening the lever, do not put your head or arm in line with the lever. If you lose your grip, the lever will open and hit you.

EQUIPMENT.— Assume the equipment has been loaded as described earlier in this chapter.

Place your tie-down assemblies to the correct tie-down on the equipment. Be sure you do not put a chain around any hydraulic, fuel, or brake lines, because they will be crushed when the binders are closed. Ensure you secured all movement symmetrically, as shown in figure 7-33, so that the equipment cannot move forward, aft, vertically, or horizontally.

CAUTION

> When transporting equipment equipped with turbochargers, seal off the exhaust stacks to prevent alterations of the turbocharger turbine due to wind velocity. Failure to do so can result in damage to the turbine bearings due to the lack of lubrication.

OVERSIZE AND OVERWEIGHT LOADS.— Oversize and overweight loads require special permits.

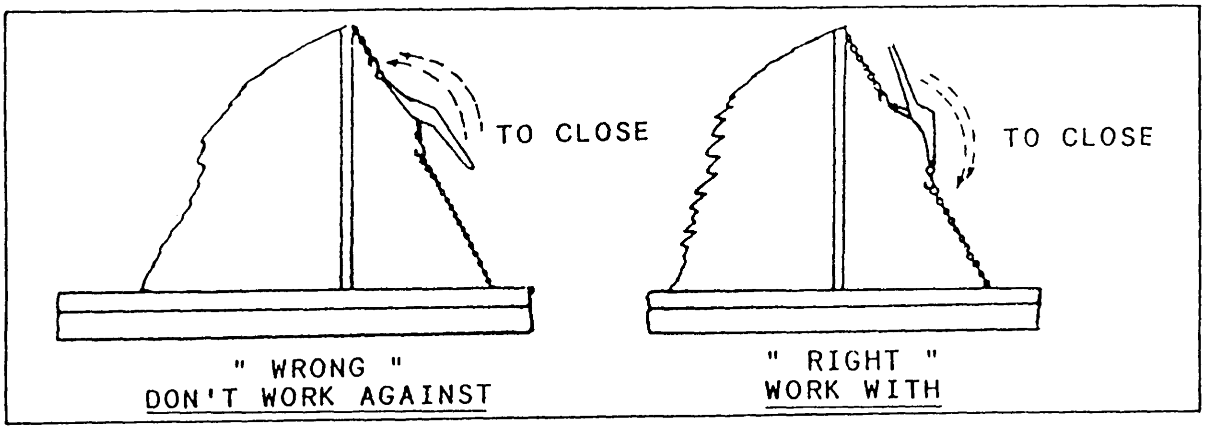


Figure 7-35.—Using load binders.

Driving is usually limited to certain times of the day and requires special equipment, such as "wide load" signs, flashing lights, flags, police escort or pilot vehicles bearing warning signs, and/or flashing lights.

NOTE: Weight, height, and width limitations are set forth by each state. Always know the weight, height, and width of the load you are pulling and the regulations for the state(s) you are to operate in.

DUMP TRUCKS

The Naval Construction Force (NCF) uses many shapes and sizes of dump trucks ranging from 2 1/2 tons to 20 tons to perform construction and disaster repair operations and up to 25 tons to support quarry operations. Although there are a different variety of types of dump trucks used, the principles of operation are the same. As an operator, you are responsible for

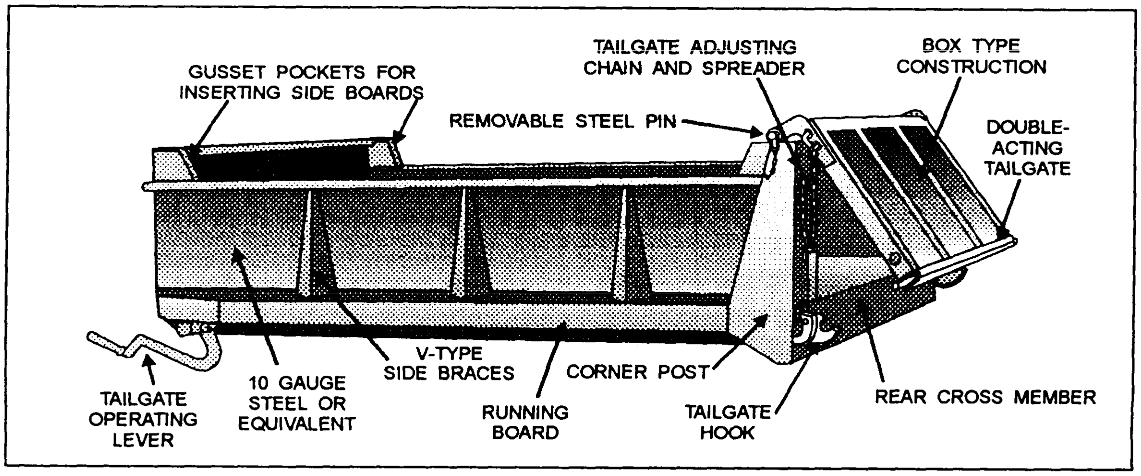

GUSSET POCKETS FOR INSERTING SIDE BOARDS
TAILGATE ADJUSTING CHAIN AND SPREADER
BOX TYPE CONSTRUCTION
REMOVABLE STEEL PIN
DOUBLE-ACTING TAILGATE
TAILGATE OPERATING LEVER
10 GAUGE STEEL OR EQUIVALENT
V-TYPE SIDE BRACES
RUNNING BOARD
CORNER POST
TAILGATE HOOK
REAR CROSS MEMBER

Figure 7-36.—Dump truck body components.

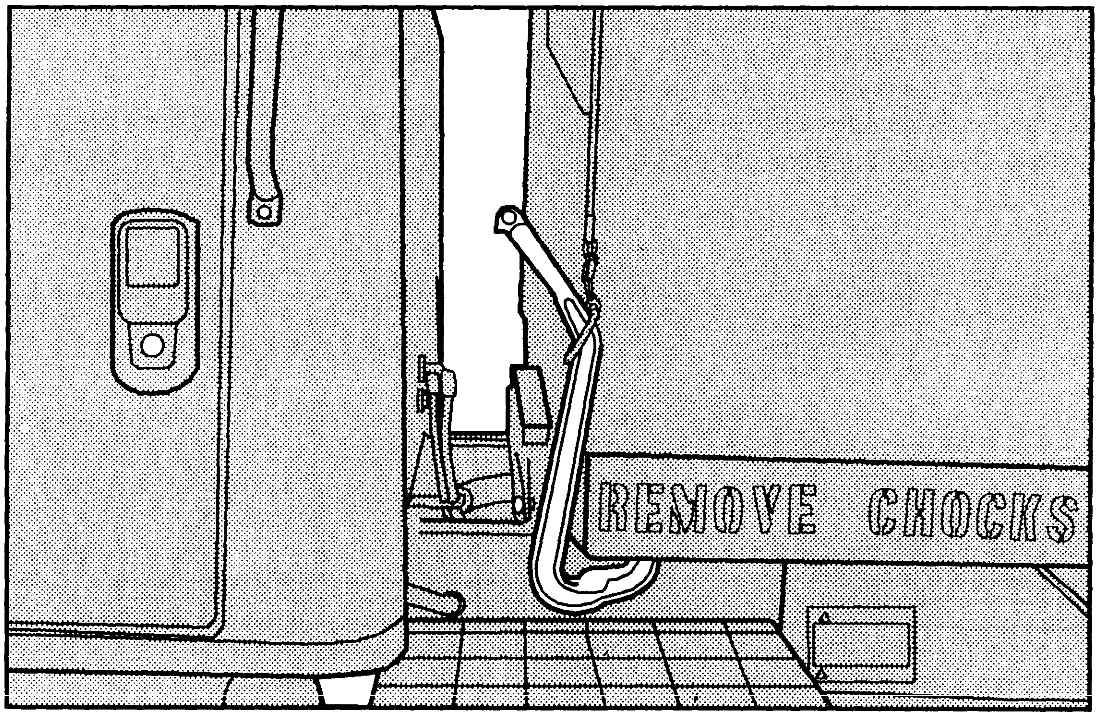

REMOVE CHOCKS

Figure 7-37.—Tailgate operating lever.

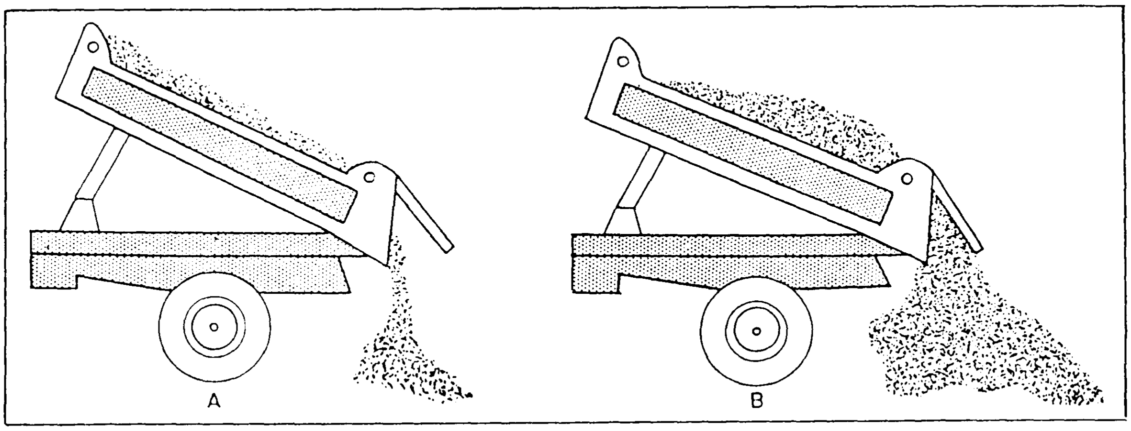


Figure 7-38.—Dumping the load.

reading and understanding the operator's manual for the model of dump truck you are assigned to operate. This section covers the basic characteristics and operations of dump trucks.

CHARACTERISTICS

A typical dump truck is equipped with a dump body that is hinged to the rear of a subframe which is mounted directly on the truck chassis. Dump bodies range in structural strength and size to support different operations. That is why it is important that the operator knows the design and capacity of the dump truck assigned to operate. You do not want to haul quarry rock in a dump body designed to haul and heat asphalt. The quarry rock can damage the dump body and render it useless for asphalt operations. The components of a dump truck body are shown in figure 7-36.

A hydraulic hoist assembly is used to raise and lower the dump truck body. The hydraulic pump is driven by a propeller shaft connected to the power takeoff (PTO). A variety of ways are used to engage the PTO on dump trucks used in the NCF; therefore, consult the operator's manual for specific instructions on how to engage the PTO and hoist assembly.

DUMP TRUCK OPERATIONS

During dumping operations, the truck should be on level ground or inclined uphill with the front of the truck facing downward. When the truck is in position, release the lower latches of the tailgate with the hand lever at the front left corner of the body (fig. 7-37.) Then engage the control for the dump truck body. Hydraulic pressure will begin to hoist the dump truck body, and as the body rises, the load will slide backward under the open tailgate (fig. 7-38, view A). If the load piles up and blocks the tailgate (fig. 7-38, view B), place the truck in low gear and move it forward until there is more space to dump the remainder of the load.

If the load does not slide out easily, have someone dislodge it with a long-handled shovel, taking care not to stand in the immediate dumping area. When dumping a load of rocks or other large solids, see that the tailgate is latched at the bottom, but unfastened at the top, so that the tailgate can drop down and the load can drop, as shown in figure 7-39.

Not all dump trucks have tailgate wings. On those that do not, you have to drop the tailgate down and support it with chains. To spread a load over a large area,

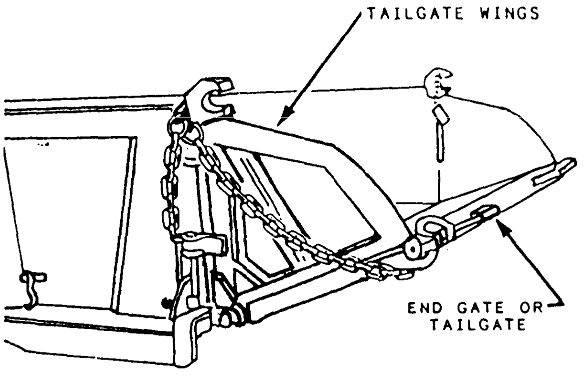


Figure 7-39.—Tailgate rigged for dumping large material.

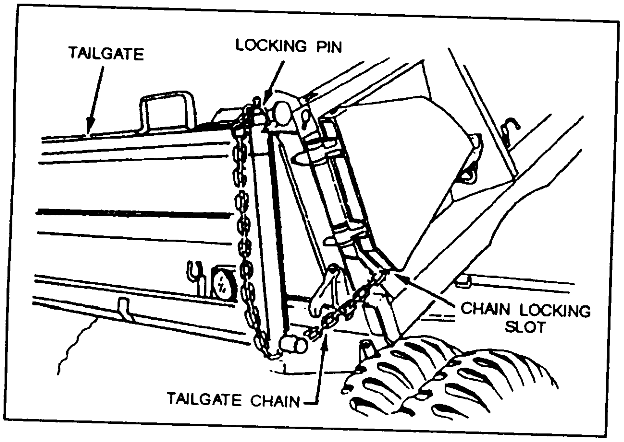


Figure 7-40.—Tailgate rigged for spreading operations.

shift the truck into low gear and drive it slowly forward while dumping, as shown in figure 7-40.

The dump truck body can be held in any position by returning the control lever to the HOLD position. When dumping is completed, lower the body by returning the control lever to the LOWERING position. Then close the tailgate latches.

The load in a dump truck should be distributed evenly. Heaped loads to the front put more strain on the hoist. Loads to one side can damage the hinge pins, the dump bed, or bend the truck chassis. Remember: If your load should be distributed unevenly and dumped on uneven ground, you could find yourself in great difficulty, as shown in figure 7-41.

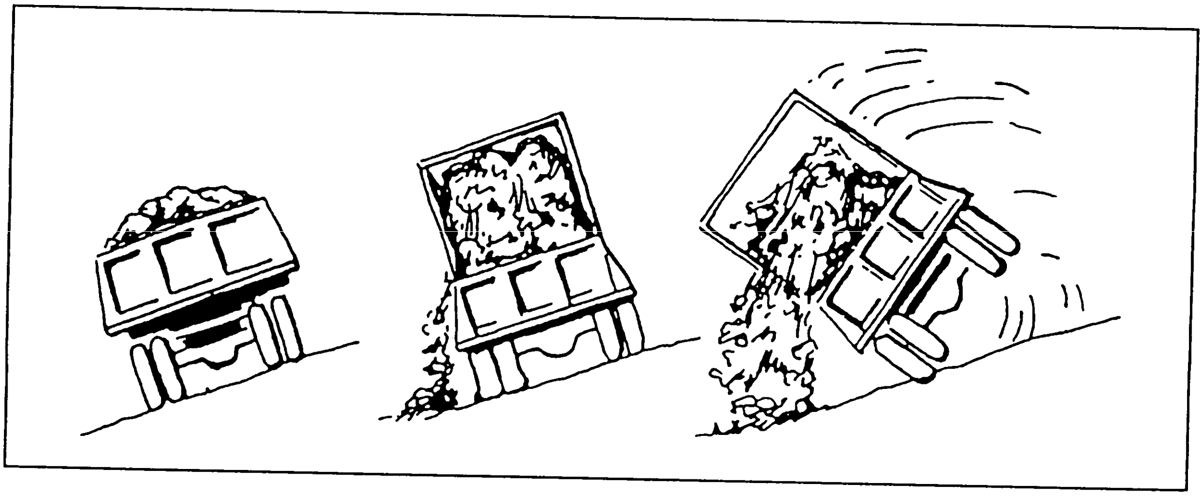


Figure 7-41.—Hillside dumping hazard.

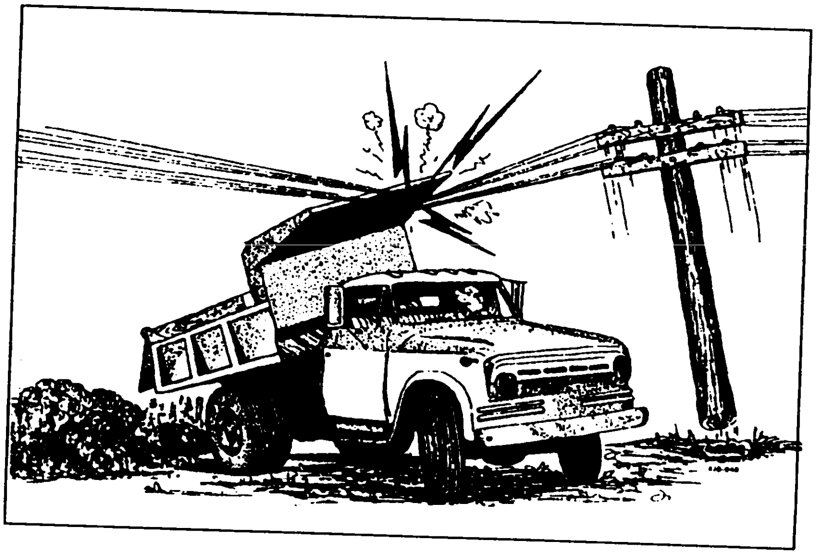


Figure 7-42.—Watch for overhead obstructions.

When regular rock dumps are not available, it may be necessary to haul large rocks in a dump body not designed for this purpose. The bed of the dump truck should then be lined with wooden planking so as not to damage the bed while the rock is being loaded. The tailgate should be latched again at the bottom but pushed out at the top, as shown in figure 7-39.

Before hauling asphalt, coat the inside of the bed with diesel fuel. The fuel prevents the asphalt from sticking to the dump bed. To control any rapid heat loss, cover the hot-mix with a tarpaulin that should be tied down securely to prevent flapping in the wind.

NOTE: Some states and countries require that all loose materials hauled in dump trucks must be covered to prevent spillage on roadways and breaking of vehicle windshields. Know the rules and regulations for the area you are to operate in.

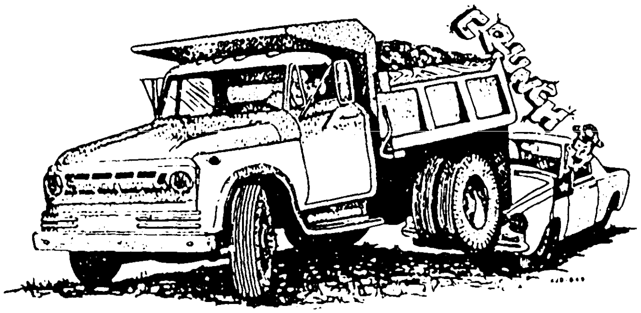


Figure 7-43.—Avoid backing accidents; use a backing guide.

When performing dumping operations, be careful of overhead obstructions, as shown in figure 7-42. Ensure the dump bed is completely lowered before proceeding. When backing, use a backing guide to avoid a backing accident similar to the one shown in figure 7-43.

CHAPTER 8

FORKLIFTS

The forklift is a primary piece of equipment that is essential to the mission of the NCF. Forklifts are used to support construction operations whenever there is a need to lift, load, or unload materials or supplies. Because of the variety of makes and models of forklifts used in the Navy and the NCF, this chapter covers only the characteristics and basic principles of operations of forklifts. By reading the operator's manuals, you can obtain detailed information about each make and model.

MATERIALS-HANDLING EQUIPMENT

Forklifts are classified as materials-handling equipment. The term materials handling describes an ongoing activity for every construction project or operation that requires the picking up and moving of raw materials, processed parts, finished products, tools, equipment, supplies, or maintenances items. Every operation that requires raising, lowering, or moving an item is classified as materials handling.

Since materials handling involves lifting, lowering, and moving in some form, forklifts excel over other methods of handling. Forklifts are specifically designed to ensure efficient handling of materials under varied conditions. Design specifications and performance characteristics of forklifts define their capabilities and limitations under adverse conditions. To operate a forklift efficiently, you must know its capabilities and limitations.

This chapter covers the capabilities, limitations, attachments, and principles of operation of warehouse and rough terrain forklifts.

WAREHOUSE FORKLIFTS

The most common types of warehouse forklifts used are either electric-, gasoline-, or propane-powered and have solid, semisolid, or pneumatic rubber tires. These forklifts are used in warehouses or on hard-surfaced outdoor storage areas. The warehouse forklift (fig. 8-1) is a unit designed to pickup, carry, and

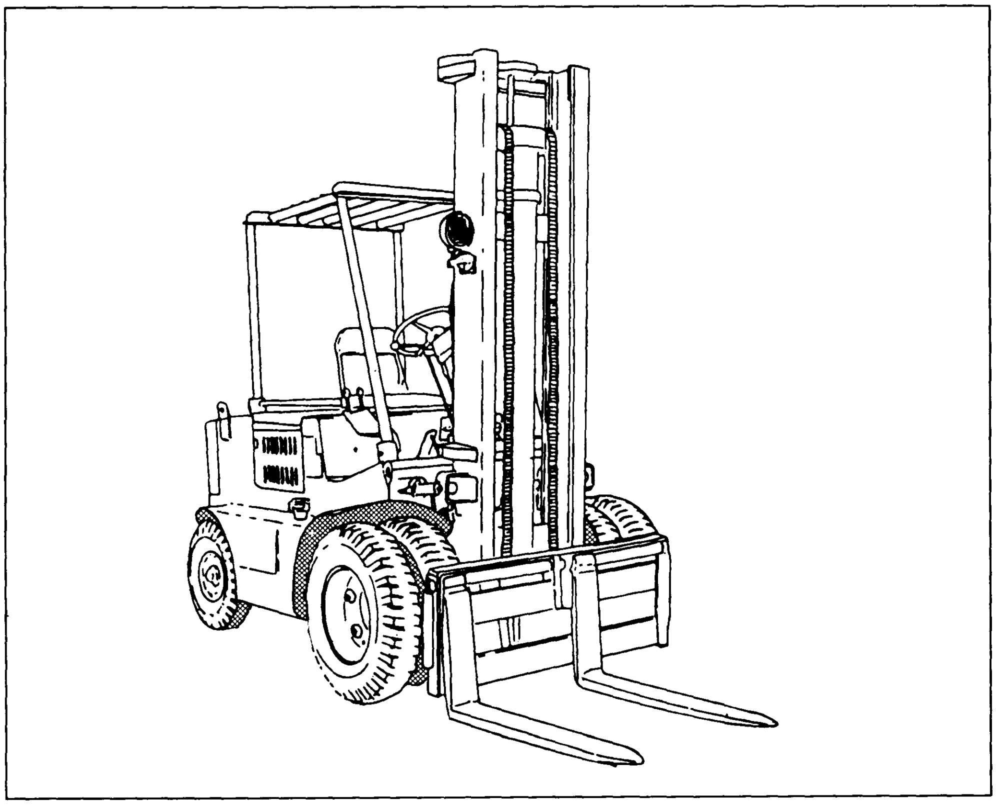


Figure 8-1.—Warehouse forklift

stack unit loads of supplies and equipment. Standard warehouse forklifts have lifting capacities from 2,000 to 15,000 pounds and lifting heights from 100 to 210 inches. Warehouse forklifts are equipped with a telescopic mast that permits loads to be lifted beyond the height of the collapsed mast. The height the forks can raise before the inner slides move upward from the mast and increase the overall height is called **free lift.**

4K ROUGH-TERRAIN (RT) FORKLIFT

The 4K rough-terrain (RT) forklift (fig. 8-2) is a diesel engine-driven, rubber-tired, self-contained, rider type of mechanized materials-handling vehicle. They are designed to lift loads of 4,000-pound capacity with a 24-inch load center to a maximum height of 100 inches. The lifting forks are mounted on the front of the vehicle and the engine faces the rear. Controls for operating the lifting forks (lifting, tilting, rotating, and side shifting) are located to the right when the operator is sitting in the operator's seat.

The 4K (RT) forklift is designed for the loading and unloading of flatcars, flatbed trailers, cargo aircraft, and landing craft. Additionally, the 4K (RT) is used for stocking, unstacking, and transporting heavy-crated boxes, containers, and palletized loads of heavy equipment and supplies over unprepared and unstable surfaces. This forklift is the primary forklift used in rough terrain, such as a beach, in deep sand, or where the terrain is covered with ice, snow, or mud, or where hard standing is not available. The 4K (RT) forklift can be used both indoors and outdoors and is capable of fording streams or pools of water up to 30 inches deep. This forklift can be transported by tractor-trailer or by military aircraft.

The 4K forklift may be driven to project sites under its own power without any special preparation; however, when performing the prestart operational check, you should ensure the safety pin (fig. 8-3) is disengaged before operating. The safety pin prevents the forklift

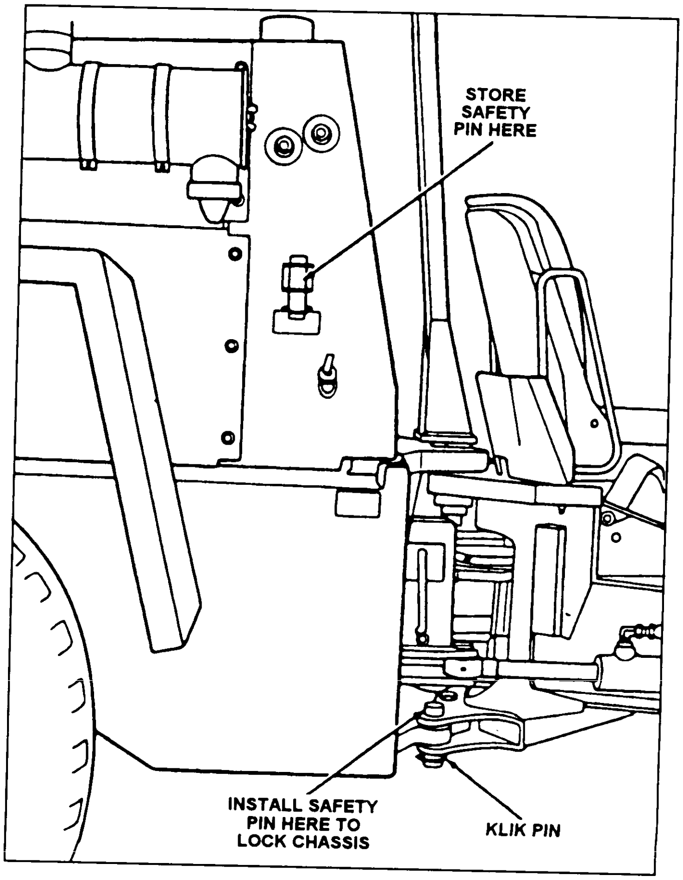


Figure 8-3.—Safety pin location.

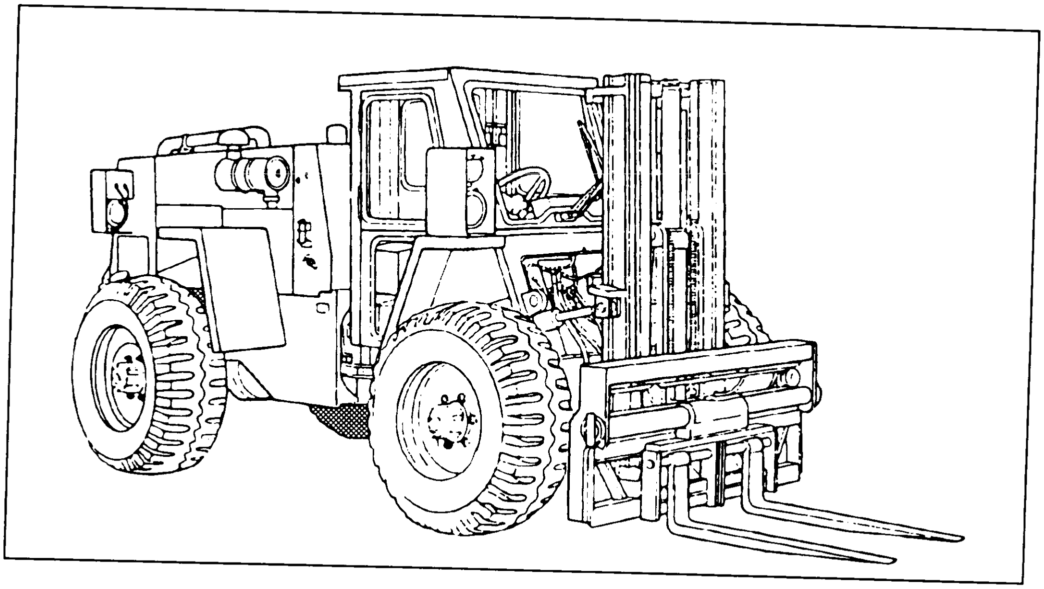


Figure 8-2.—4K rough-terrain (RT) forklift.

from articulating; therefore, the forklift cannot be steered. Failure to disengage the pin may cause serious injury or death.

The 4k forklift can be towed rearward using the tow bar (fig. 8-4) located on the rear of the vehicle.

The towing procedure for the 4K (RT) forklift is as follows:

1. Remove the pin securing the tow bar in the vertical position and lower the tow bar into the towing position and attach it to the pintle hook on the towing vehicle.

2. Disconnect the hook end of the two safety chains from the forklift and attach them to the towing vehicle.

3. Push the **axle disconnect lever** (fig. 8-5) to the right toward the front chassis to disconnect the axles for towing.

The axle disconnect lever controls the engagement of the transmission output shaft to the front and rear axles. To engage the axles for operation, you push the lever to the left towards the rear of the vehicle.

4. Open the steering **bypass valve** (fig. 8-6) by turning it counterclockwise fully.

The steering bypass valve allows the front chassis to pivot freely on the rear chassis when towing the forklift. For normal steering control, close the valve by turning the knob clockwise fully.

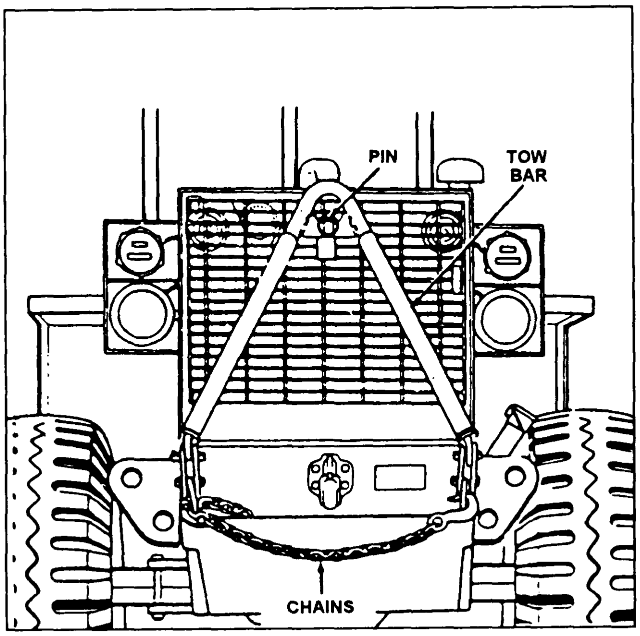


Figure 8-4.—Tow bar and chains.

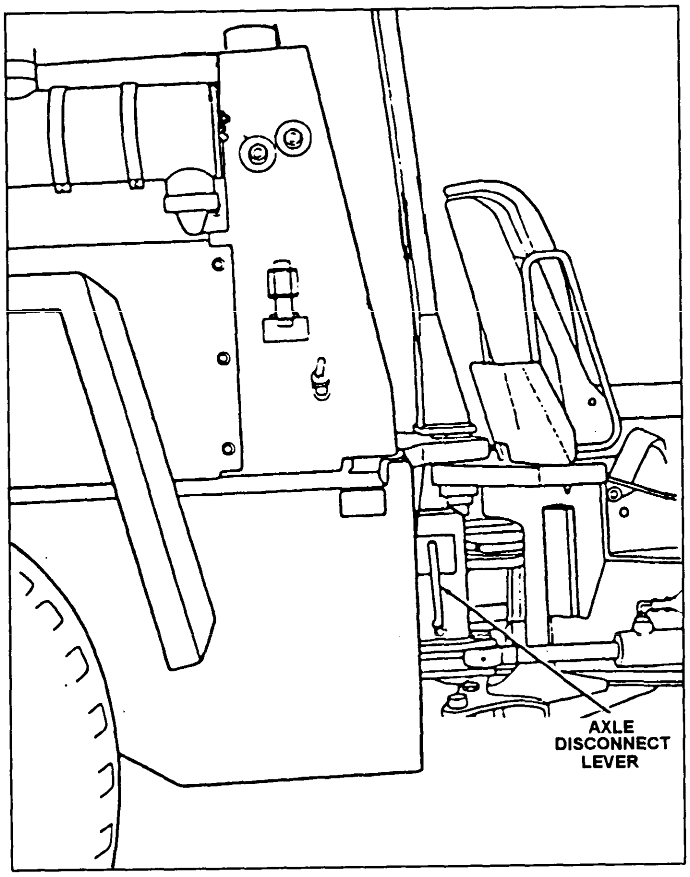


Figure 8-5.—Axle disconnect lever.

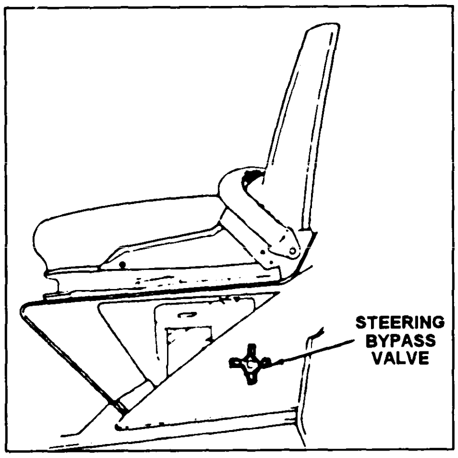


Figure 8-6.—Steering bypass valve.

CAUTION

Verify that the steering bypass valve is closed before operating the 4K forklift.

5. Remove the safety pin (fig. 8-3), if installed. **The safety pin must not be installed when the forklift is being towed.**

CAUTION

Before pushing the forklift, install the safety pin to prevent the forklift from articulating and damaging the tow bar.

NOTE: Do not tow the forklift faster than 35 mph.

6K ROUGH-TERRAIN (RT) FORKLIFTS

The 6K rough-terrain (RT) forklifts (fig. 8-7) are all-wheel drive, all-wheel steer materials-handling equipment capable of lifting 6,000-pound loads to a height of 200 inches.

The 6K (RT) forklift is designed to handle loads over rough terrain consisting of unprepared or unstabilized surfaces, such as beaches, deep sand, snow, ice, or mud. The 6K (RT) is used primarily for loading and unloading flatbed trailers, landing craft, and other types of cargo vessels.

A hydraulic-operated forklift mechanism, mounted on the extreme front of the 6K (RT) forklift, provides for lifting, reaching, tilting, and sliding loads during material-handling operations.

A unique design feature of the rough-terrain forklift is an oscillating hydraulic cylinder that allows the rotation of the forklift frame about its longitudinal axis when being operated over rough terrain. The operator controls the rotation by manipulating the control that activates the oscillating hydraulic cylinder. The 6K (RT) forklift is also equipped with a power shift

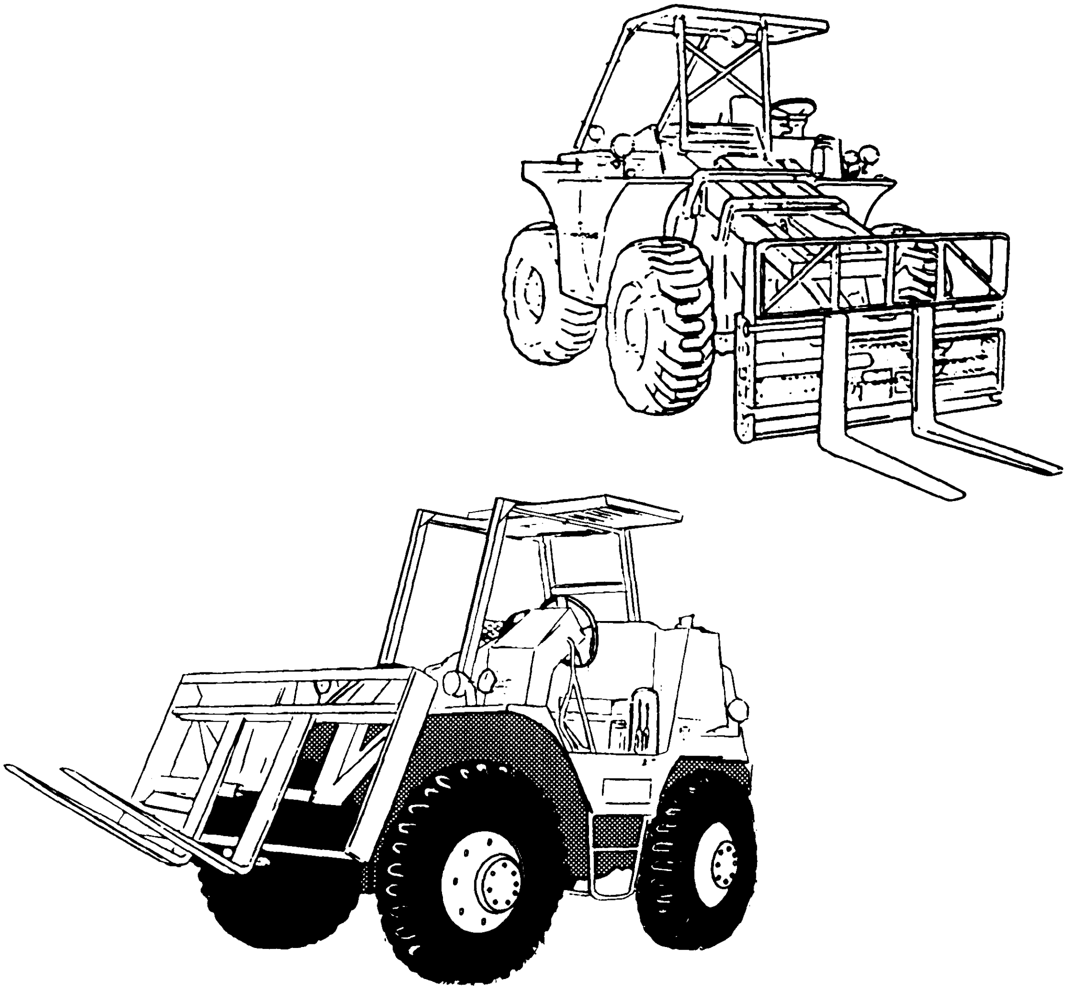


Figure 8-7.—6K rough-terrain (RT) forklifts.

transmission for smooth acceleration, deceleration, and easy handling.

LIFT-KING FORKLIFT

The NCF has two types of lift-king forklifts (fig. 8-8) rated at 12K and 16K. These two models provide a lifting capacity of 12,000 to 16,000 pounds at a 48-inch load center to a height of 120 inches. The lift-king forklift is equipped with forklift oscillation, load side shift, lift interrupt, fork positioning, four-wheel and two-wheel-crab steering selection, and counterweight lowering.

The lift-king forklift is equipped with an inching control that is controlled by the inching pedal located to the left of the brake pedal. Depressing the inching pedal slightly varies the amount of oil pressure in the transmission, allowing the forklift to be "inched" along slowly while the engine is operated at high speed for fast lifts. When the inching pedal is depressed fully, the transmission is disengaged.

NOTE: Do not use the inching pedal as a clutch and under high-torque requirements.

The mast of the lift-king forklift is equipped with a lift interrupt device that prevents lifting the fork assembly above 43 inches from the ground. This is a safety device to prevent raising the mast while inside an aircraft and causing extensive damage. To lift loads higher than 43 inches, you must press the red-colored manual lift interrupt override button. This button allows the forks to attain their maximum lift height when required.

The lift-king forklift is air transportable; however, where the load per axle weight cannot be exceeded, the front carriage assembly and rear counterweight must be removed. The procedure of carriage removal is as follows:

1. Lower the forks to the ground and tilt the mast slightly forward to produce slack in the lifting chains.
2. Remove the lower chain anchor pins.
3. Raise the mast above the carriage rollers and back the forklift out, leaving the forks and carriage on the ground.

NOTE: For reinstallation, the procedures are simply reversed.

The procedure for counterweight removal is as follows:

1. Remove the two bolts (one on each side of the forklift) that secures the counterweight (fig. 8-9).
2. Lower the counterweight lifting arm to rest the counterweight on the ground (hydraulic control lever is located in the back of the operator's cab to the right of the seat).
3. Remove the pin from the shackle to disconnect the arm from the counterweight. Remember: Store the bolts and the pin in the toolbox.
4. Drive the forklift away from the counterweight.

NOTE: When the lift-king forklift is transported on a tractor-trailer, seal the exhaust pipe to prevent autorotation of the turbocharger turbine due to wind velocity. Failure to do so can result in damage to the turbine bearing due to lack of lubrication.

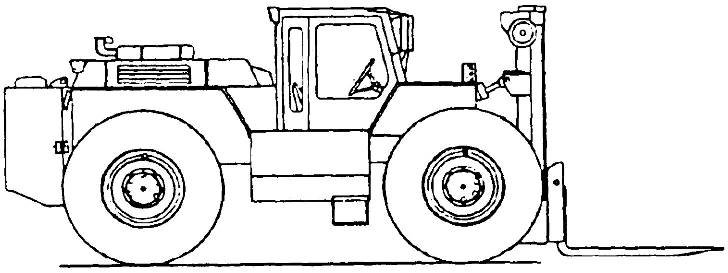


Figure 8-8.—Lift-king forklift.

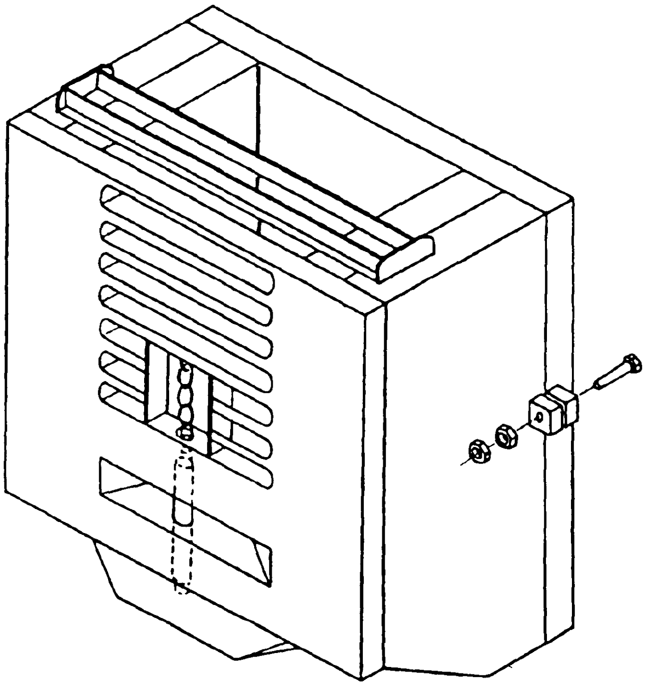


Figure 8-9.—Counterweight.

ATTACHMENTS

Attachments give forklifts versatility that allow them to do more work efficiently; however, you must remember that the attachment may reduce the capacity of the forklift by changing the center of gravity of the load.

Fork Extensions

Forklift extensions that are known by the term **tine (fork) extender** are designed in two configurations: bare tine extender (fig. 8-10) and rollerized tine extenders (fig. 8-11).

An extender provides additional length to the forklift tines that permits an easier way to load tractor-trailers and Air Force 463-L pallets. The extender moves the center of gravity of the load, and this restricts the weight that can be lifted. You must remember these restrictions when using the extensions to handle large or bulky loads. The lift-king forklift has a set of roller tine extensions assigned as an attachment. The roller tines are used when handling 463-L pallets.

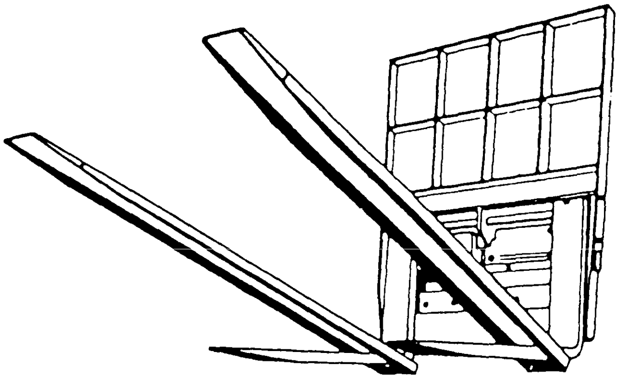


Figure 8-10.—Bare tine extender.

Crane Boom Attachment

The crane boom attachment converts the forklift to a mobile crane jib capable of handling bulky, irregularly shaped objects and is a valuable aid in maintenance work (fig. 8-12). The crane boom is raised or lowered with the standard lift mechanism.

Drum-Handling Attachment

A drum-handling attachment can handle filled 55-gallon drums by means of a forklift truck. Three types of drum-handling attachments are shown in figure 8-13.

The first consists of a series of specially shaped and spaced forks that cradle the drums to be handled (fig. 8-13, view A). This attachment handles three filled drums at one time.

The second type is mounted on the forks of the forklift and consists of side rails from which specially designed hooks are suspended at the front and rear (fig. 8-13, view B). The attachment is lowered over the drums until the hooks drop into position over the drum rims. This attachment can handle two filled drums at one time.

The third type is vertically operated and handles one filled drum at one time (fig. 8-13, view C).

PRINCIPLES OF OPERATION

Forklifts operate on the simple principle of a fulcrum or like a playground teeter-totter. A unit load

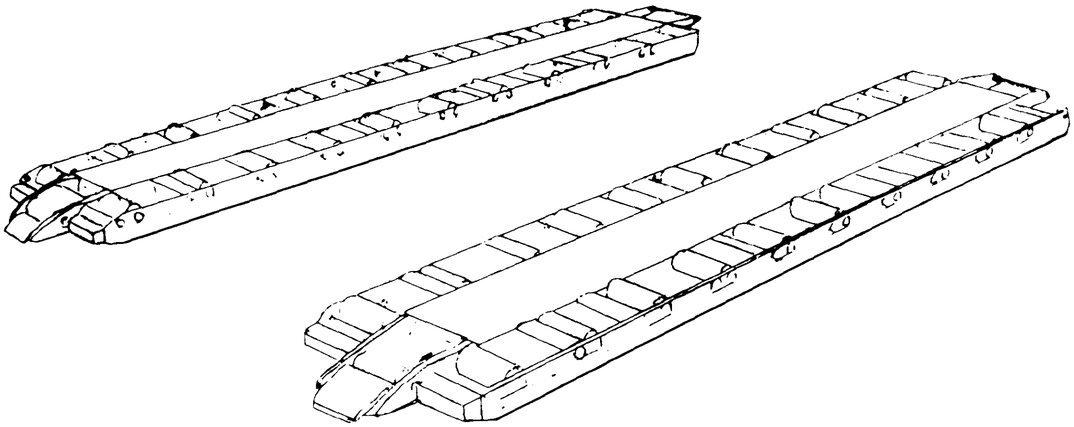


Figure 8-11.—Rollerized tine extenders.

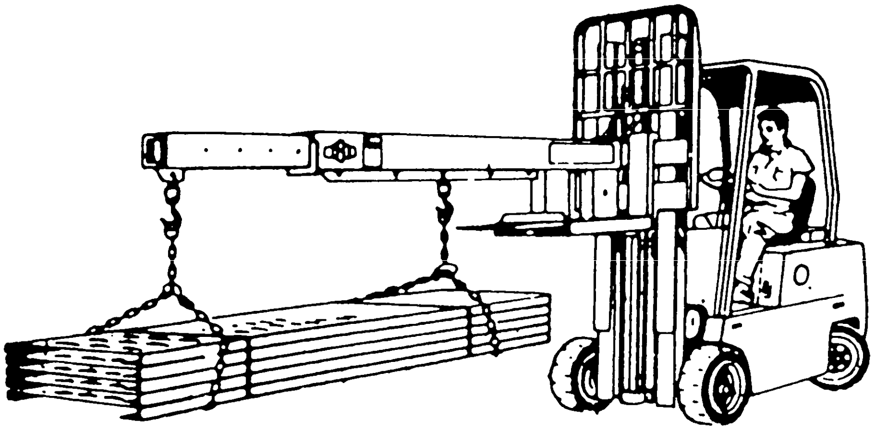
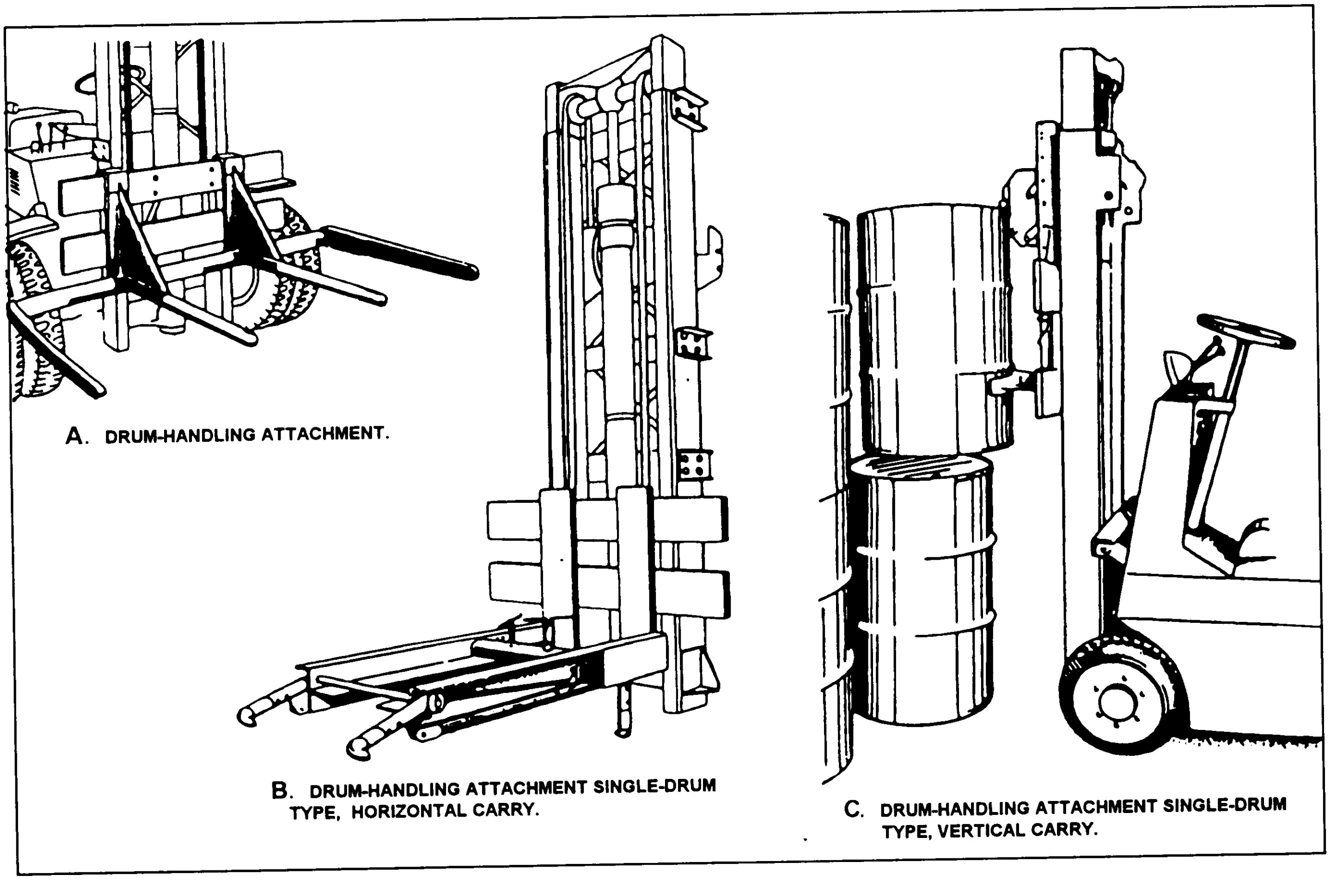


Figure 8-12.—Crane boom attached to the forklift.

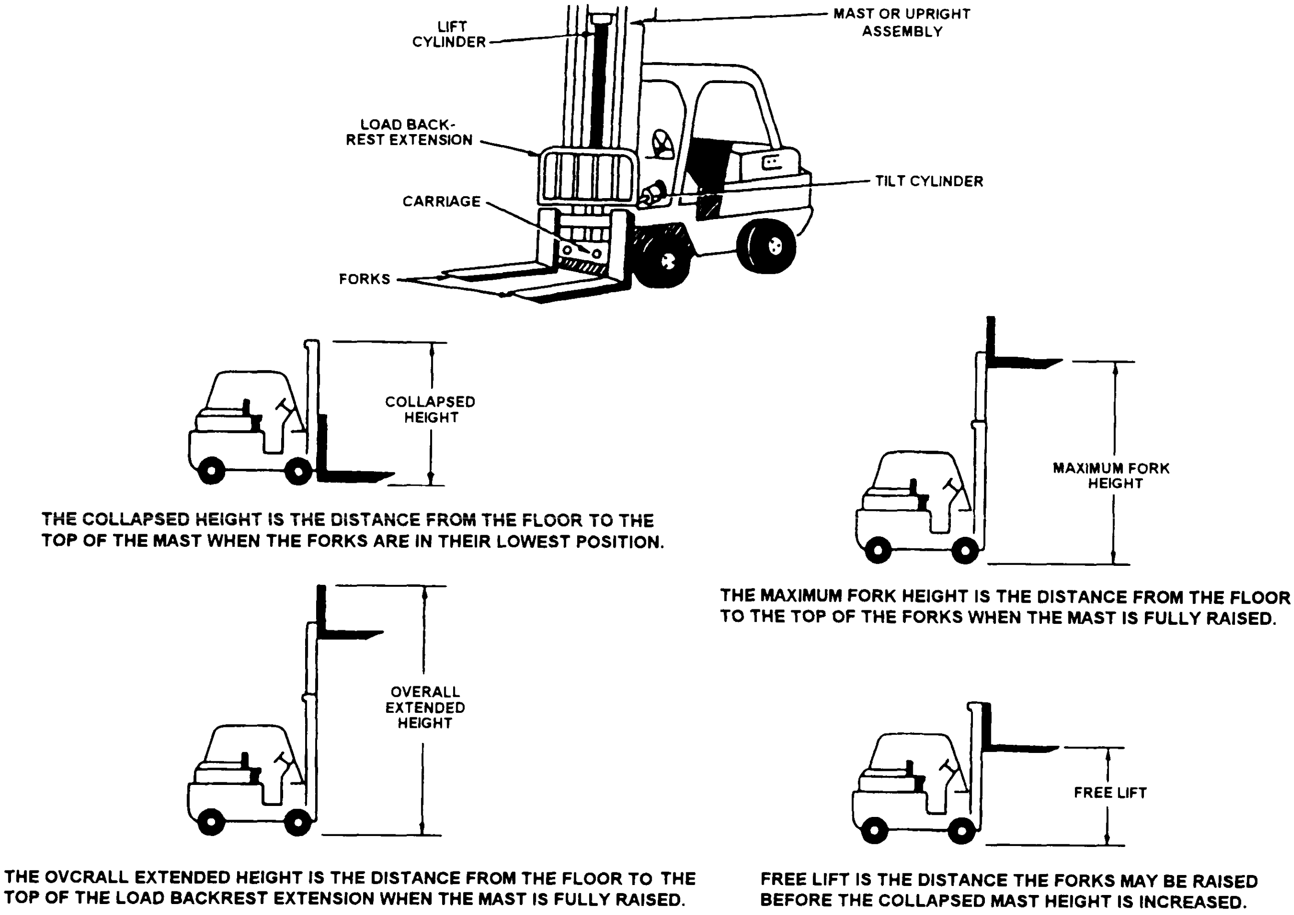


A. DRUM-HANDLING ATTACHMENT.
B. DRUM-HANDLING ATTACHMENT SINGLE-DRUM TYPE, HORIZONTAL CARRY.
C. DRUM-HANDLING ATTACHMENT SINGLE-DRUM TYPE, VERTICAL CARRY.

Figure 8-13.—Drum-handling attachments.

on the forks must be counterbalanced by the counterweight and weight of the forklift. The fulcrum, or pivot, is the drive axle.

A forklift must be physically small and compact to work in confined areas, such as boxcars, container vans, and narrow aisles. Additionally, the forklift must offer enough working space for both the operator and maintenance personnel. It must handle maximum loads and stack them safely and still have an upright, minimum load, and collapsed height to maneuver in



THE COLLAPSED HEIGHT IS THE DISTANCE FROM THE FLOOR TO THE TOP OF THE MAST WHEN THE FORKS ARE IN THEIR LOWEST POSITION.

THE MAXIMUM FORK HEIGHT IS THE DISTANCE FROM THE FLOOR TO THE TOP OF THE FORKS WHEN THE MAST IS FULLY RAISED.

THE OVCRALL EXTENDED HEIGHT IS THE DISTANCE FROM THE FLOOR TO THE TOP OF THE LOAD BACKREST EXTENSION WHEN THE MAST IS FULLY RAISED.

FREE LIFT IS THE DISTANCE THE FORKS MAY BE RAISED BEFORE THE COLLAPSED MAST HEIGHT IS INCREASED.

Figure 8-14.—Technical terms used in forklift operations.

areas with low-overhead clearance. It must be able to negotiate inclines, either empty or loaded. Technical terms associated with forklift operations are explained in figure 8-14.

CAPABILITIES AND LIMITS

The safe and efficient use of a forklift requires skill and alertness horn the operator. For the majority of materials-handling operations, the forklift excels, because it is self-propelled and requires only the operator to control the lifting, transporting, stacking, and unstacking. To develop the skill required for safe and efficient forklift operations, you must have an understanding of the makeup, capabilities, and limitations of the forklift, and see that it is maintained in good mechanical condition.

In the selection of a forklift, consider the performance, lift height, power, and capacity; also consider the available space and area the forklift must operate in.

NOTE: For complete information on the capabilities of your forklift, refer to the operator's manual provided by the manufacturer.

Lift Height

Forklifts are available in standard models that have lift heights of up to 210 inches. The lift height of a forklift selected for an operation depends on how high the material is stored and the overall height of the forklift, with the mast lowered, that must clear door casings, overhead obstructions, and other building limitations. Also, there are restrictions and limitations on lift height during unloading and loading of cargo vessels, trucks, tractor-trailers, and so forth.

Capacity

The capacity of the forklift must be equal to the task. For this reason, the weight of each load must be known before a lift is made.

The center of balance is a critical factor for capacity. On most forklifts, the **center of balance (C/B)** is under the operator's seat, as shown in figure 8-15. When a load is lifted a combined center of balance (C C/B) is created, as shown in figure 8-16. When the load is raised, the C C/B changes, as shown in figure 8-17.

A forklift is designed to lift its maximum capacity with the load centered on the forks, not with the tip of the forks.

CAUTION

Never lift a load with the load balanced on the tips of the forks.

You should know where the center of balance (C/B) is before trying to lift any load. The C/B of the load should be as far back on the forks as possible. If the C/B is on one side, as shown in figure 8-18, the load may flip off the forks and land on its side once you lift it. The C/B of the load should be placed directly in front of the C/B of the forklift, as shown in figure 8-19. Additionally, the C/B should be centered and placed as far back as possible on the forks.

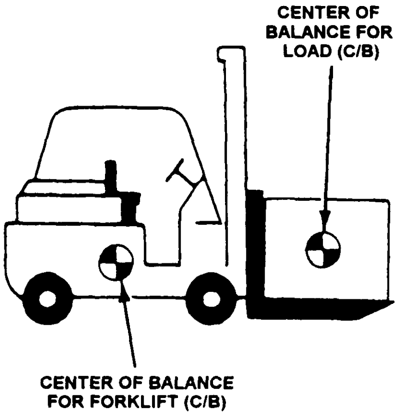

CENTER OF BALANCE FOR LOAD (C/B)
CENTER OF BALANCE FOR FORKLIFT (C/B)

Figure 8-15.—Center of balance (C/B) for the forklift and load.

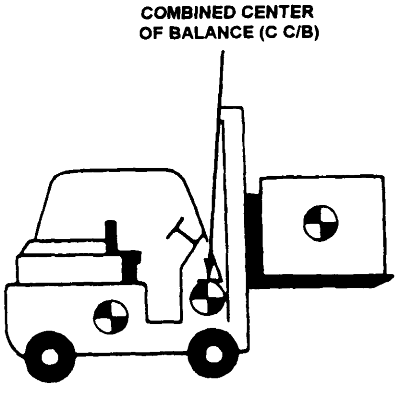


Figure 8-16.—Combined center of balance (C C/B).

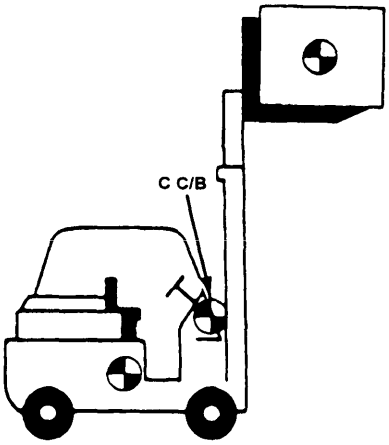


Figure 8-17.—Movement of the combined center of balance as the load is raised.

OPERATING TECHNIQUES

Before operating a forklift, you must have proper authorization and possess a thorough understanding of the operator's manual and safety precautions. If you have very little experience in operating forklifts, make sure a qualified operator guides you through at least several operating and load-handling operations before

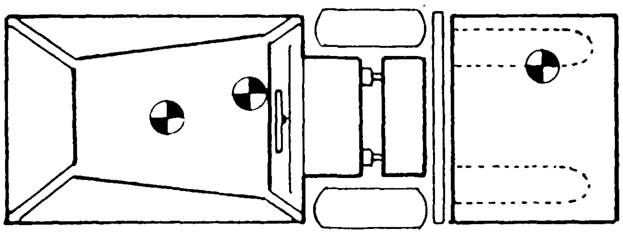


Figure 8-18.—Top view of how the combined center of balance moves with the C/B of the load.

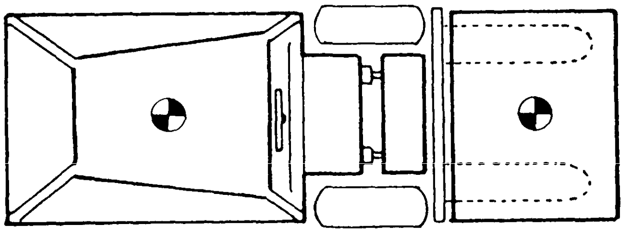


Figure 8-19.—How the C/B of the load should be centered

attempting to operate the forklift on your own. Basic education in safe operation and load-handling techniques is absolutely necessary to prepare you for proper operation and enables you to anticipate the unexpected.

NOTE: A forklift is only as safe as its operator. Only authorized, properly trained licensed personnel are permitted to operate it.

Pallets and Boxes

Most of the loads that you will handle are on pallets or in boxes. A standard pallet is 40 inches by 48 inches, as shown in figure 8-20. Mount-out boxes are in all different sizes; however, they have stringers like pallets.

LIFTING.— The technique for lifting a pallet is as follows:

1. Position the forklift squarely in front of the load and raise the forks to the proper level, halfway between the top and bottom boards of the pallet.

2. Slowly insert the forks into the pallet until the load rests against the fork faces. If the mast is not in a vertical position, the forks may hang up in the pallet when they are inserted.

NOTE: If the pallet or load is against a wall or obstruction and the forks are longer than the pallet, you will have to pick up the pallet and back up the forklift until there is enough room to reposition the forks entirely under the pallet.

3. Lift the load just enough to clear the floor (or stack beneath the load being removed). Then tilt the mast or forks back enough to cradle the load. The load should always be carried as low as possible for maximum stability and vision.

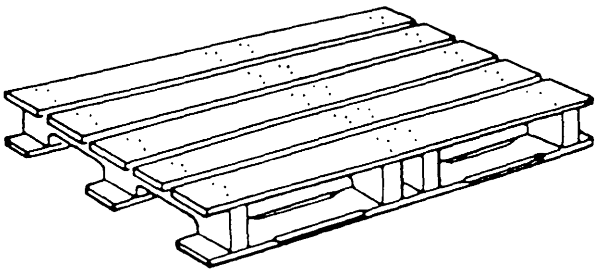


Figure 8-20.—40- by 48-inch pallet.

WARNING

Overloading a forklift is strictly prohibited. The forklift can safely lift and carry no more than its rated capacity. Among the dangers of overloading are injury to the operator, damage to the cargo, and damage to the pump and lift mechanism. Additionally, overloading causes wear on the tires, engine, or electric motor. Also, a forklift will tip forward if the load on the forks exceeds the lift capacity of the forklift. The manufacturer has established the forklift rating (expressed in pounds of load on the fork) and the allowable distance in inches from the heel of the forks to the center of gravity of the load. This distance is known as the **load center.**

CARRYING.— Carrying material with a forklift to move it from one location to another requires skill and concentration. The techniques for carrying loads with a forklift are as follows:

1. Tilt the mast as far back as the load will permit when carrying a load, and raise the load only high enough to clear obstructions. Always change speed gradually, as sudden starts and stops will cause the load to shift. Gradual starts and stops also prevent rapid wear of equipment components.

2. Always know the ground clearance of your forklift truck and the surface you are traveling on.

NOTE: If the load is so bulky that your vision is obstructed, drive in reverse. Extra care must be taken when driving in reverse, because the operator does not have a constant view of the load; therefore, a backing guide is usually needed.

3. You should ascend and descend a grade with the load pointing upgrade when operating a loaded forklift on an incline (fig. 8-21). Normally, direction of travel should be determined by what direction the operator can see best. This is why forklifts are built with reverse as well as forward travel. But, on grades of 10 percent or more, both forklift and load stability demand that the load be kept upgrade.

4. Handle each load within the rated capacity of the forklift. The **rated capacity** is the weight the forklift can handle safely. The forklift data plate rating indicates the maximum safe load that can be lifted. This maximum rating should never be exceeded; however, there are conditions requiring a load less than the rated capacity. The data plate rating does apply for weak

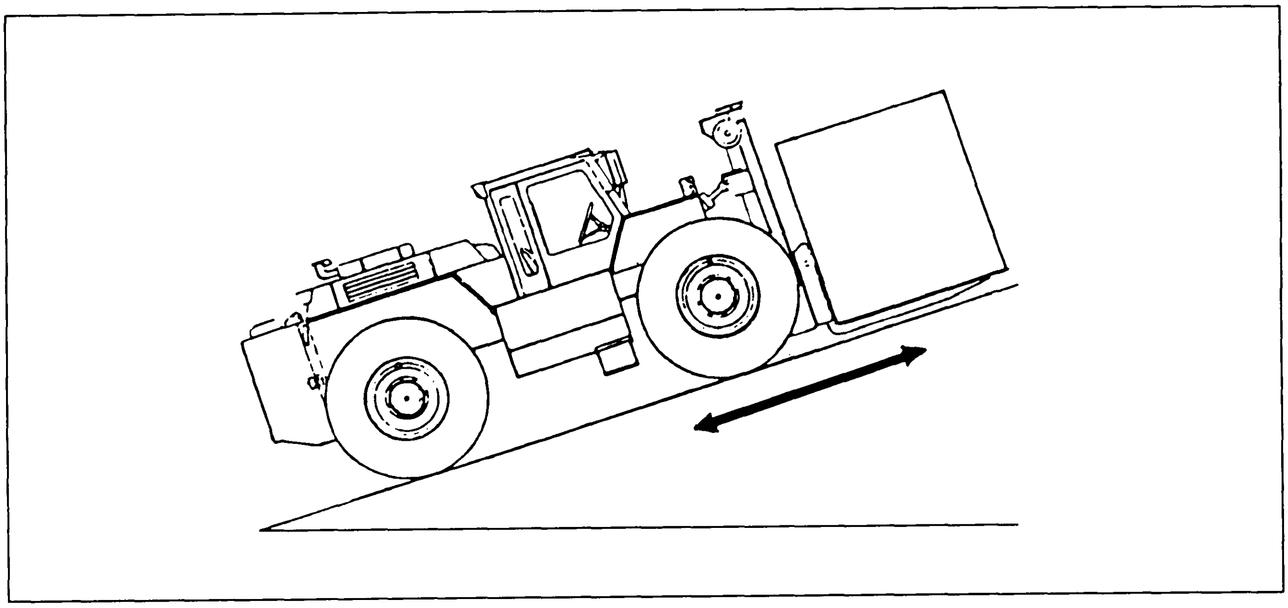


Figure 8-21.—Direction of travel on a grade.

floors, uneven terrain, special load-handling attachments, or loads with a high center of gravity. Under these conditions, the safe working load is well below the rated capacity. Under special conditions, you must reduce your load so your forklift will remain stable.

5. Handle only stable loads. Many loads are made up of unstable items that can be easily dislodged. This rule is critical to your safety when the forklift is not equipped with an overhead guard or roll over protection structure (ROPS).

6. Center the weight of wide loads between the forks; otherwise, the load may topple off the forks when you turn a corner or hit a bump.

7. Watch "swing" when handling long loads. Failure to watch clearance at the ends of your load can cause you to strike persons or objects.

8. Keep the load against the carriage by maintaining a slight backward tilt.

9. Do not travel with the load raised higher than 6 inches from the floor until you are ready to deposit the load. When loads are carried in an elevated position, the stability of the forklift is reduced. The load or part of it can fall on someone or something.

10. Drive carefully, observe traffic rules, and be in full control of the forklift at all times.

POSITIONING.— When loading and stacking material, move the forklift truck forward until the load arms are entirely under the load to be lifted. Ensure the load is centered on the arms and that it is well-seated against the face of the lifting carriage. When picking up round objects, first tilt the uprights so the forks slide along the floor or ground under the object to be lifted, as shown in figure 8-22. Then decelerate, tilt backwark, and accelerate until there is enough backward tilt of the mast to allow safe handling of the load.

NOTE: Lifting speed is controlled by the speed of the engine and the extent the control lever is pulled. Engine speed has no effect on lowering speed.

Never race the engine while hoisting a load. Too much engine speed will not increase the speed of the hoisting mechanism but may result in fast wear and possible damage to the engine. From practice and experience, you will be able to determine the best hoisting speed by sound, sight, and feel. When a load has been raised to the desired height, ease the hoist lever to the neutral position and move the forklift to the base of the stack the load is to be placed.

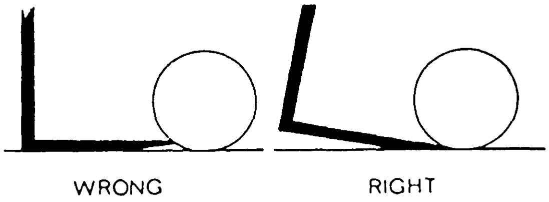


Figure 8-22.—Tilt position for picking up round objects.

Although a load maybe placed on or removed from a stack by using the hoist lever, you will learn from practice that a load can be placed or removed entirely with the tilting mechanism. The tilting mechanism is designed to raise the load arms slightly, as the mast is tilted backwards.

Practice raising the load while the forklift draws near the stack to reduce strain on the engine and the brakes. Study the problem of load handling, and keep in mind that carefully planned operations produce the most work with the least fatigue to yourself.

Lift and lower with the mast vertical or tilted slightly back. Tilt elevated loads forward only when they are directly over the unloading place. If the load or lifting mechanism is raised to pick up or deposit a load, reduce the tilt in either direction. Remember the side stability of the load and do not tilt back any farther than is necessary.

CAUTION

> Under no condition should additional counterweights be added to any materials-handling equipment to increase its stability or lifting capacity.

Long Objects

As a forklift operator, you may be tasked to move lumber, steel, piling, or pipe. You must know where the center of balance (C/B) is to move long loads. Moving long objects takes special forklift operator skills.

CARRYING.— The load on the forklift shown in figure 8-23 is too wide for the door of the warehouse. In this case, the techniques of operation shown in figure 8-24 should be followed so the forklift and long load can be maneuvered through the door. With practice, this technique can be used to maneuver around most obstacles.

POSITIONING.— The positioning of long objects for loading can be a problem, and it is best to place dunnage under the object if it is not on a pallet. The thickness of the dunnage should allow the forks to slide out freely from the load. To load a piece of pipe, piling, or anything round, you must place blocking or dunnage to prevent the round object from rolling. Then tilt the forks forward until they are flat on the floor and slide them from underneath the object.

FORKLIFT SAFETY

Safety is a vital part of forklift operations. Many forklift safety practices are as simple and clear as those for driving the family automobile. For instance, before you start your car, you check to see if the transmission is in NEUTRAL or PARK. When stopping your car, you do so gradually, not abruptly. Because a forklift is a special machine designed for a different purpose, you must exercise more caution and receive more training to operate a forklift properly.

The techniques for safe forklift operations are as follows:

1. Avoid lifting or hitting anything that is likely to fall on you or other personnel in the area. Remember that a forklift equipped with an overhead guard or ROPS

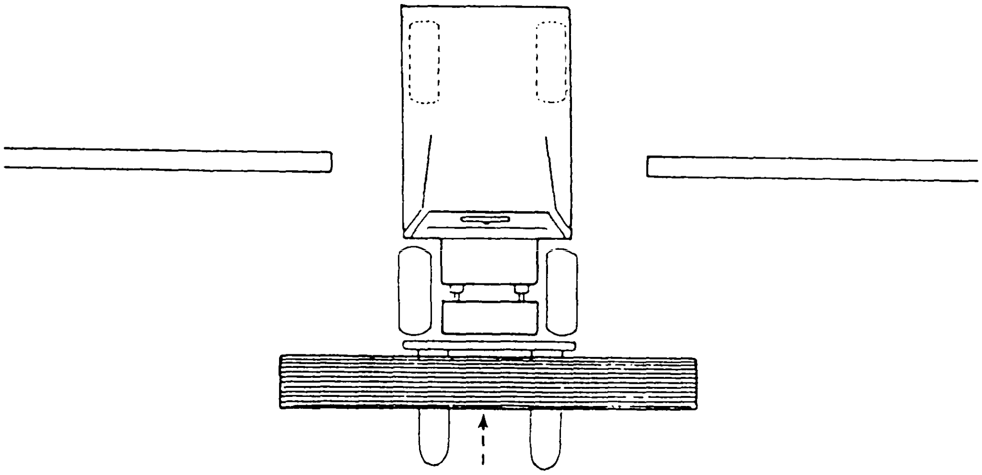
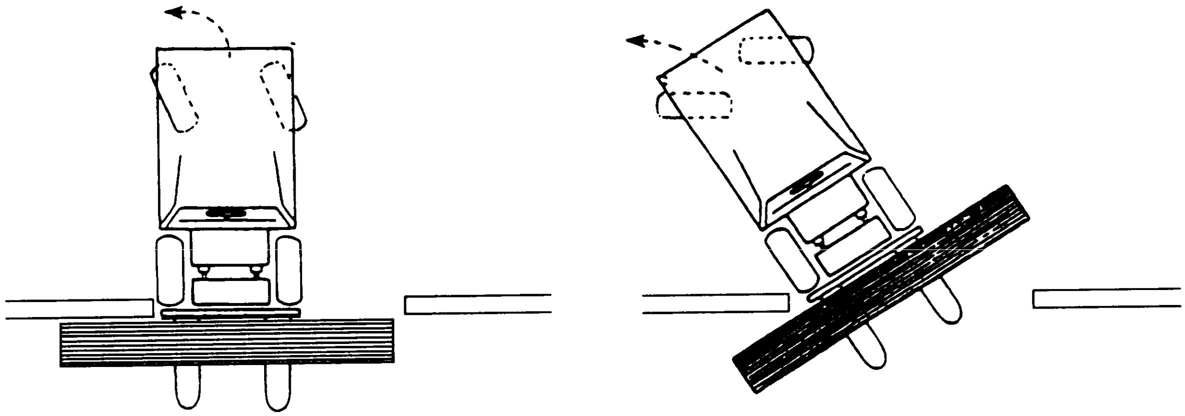
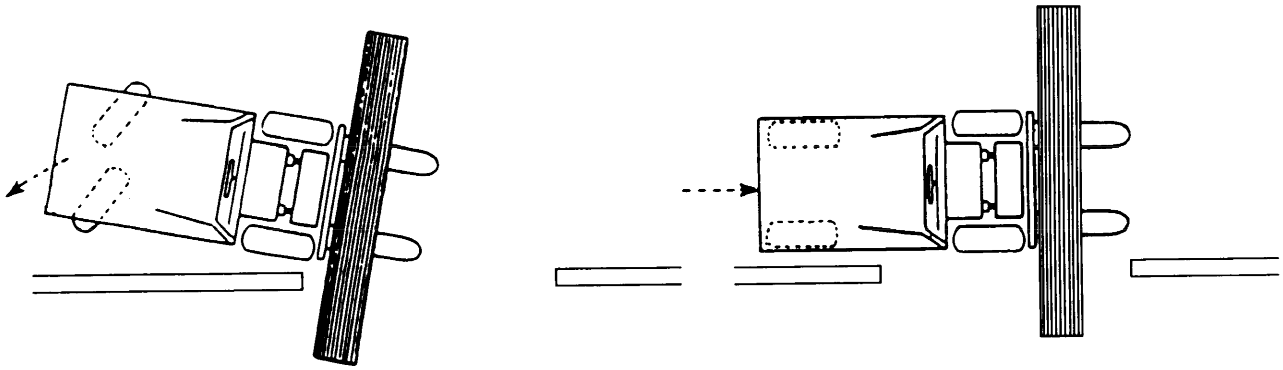


Figure 8-23.—Load too wide to maneuver through a warehouse door.



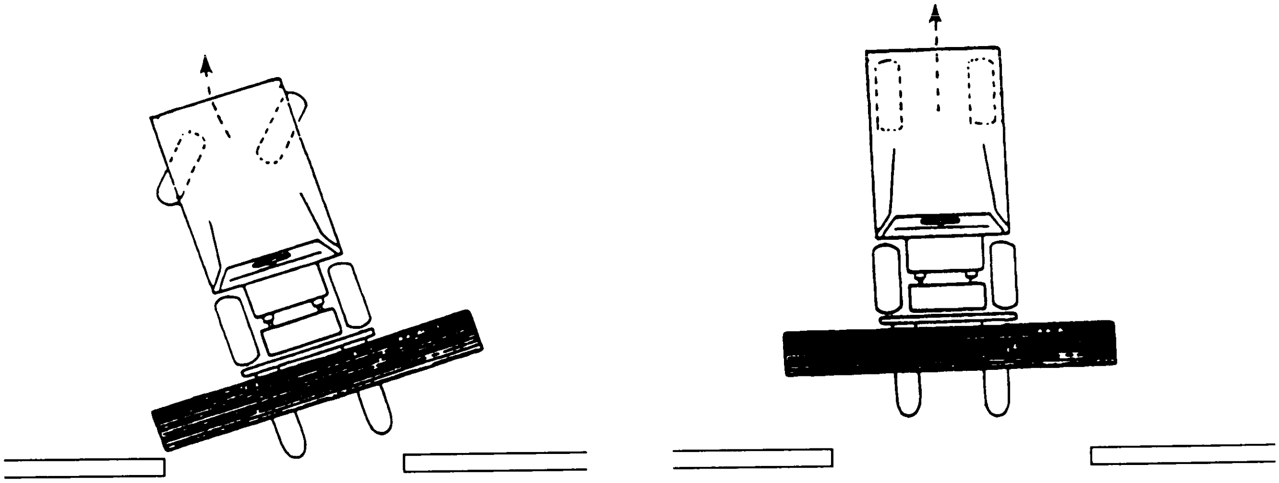
1. MOVE FORKLIFT AND LOAD CLOSE TO SIDE OF DOOR.

2. MAKE TURN SHARP TO SWING LOAD.



3. COMPLETING THE TURN.

4. MOVE LOAD TO OTHER SIDE OF THE DOOR.



5. SWING REMAINING PORTION INTO DOOR.

6. LOAD THROUGH DOOR AND INTO BUILDING.

Figure 8-24.—Technique of maneuvering a wide load through a warehouse door.

and load backrest extension provides reasonable protection against a falling object but cannot protect you against every impact. A forklift without an overhead guard provides no protection. For this reason, you should never attempt to pickup any loose, unstable, or stacked load if it appears that any part of the elevated load might topple through or over the top of the upright or fall on anybody standing nearby. You should also avoid hitting certain objects, such as stacked material, that could become dislodged and fall. Do not move your forklift around with the load carriage elevated. These rules apply whether or not your forklift is equipped with an overhead guard and are important if you are not protected by an overhead guard. Enforcing these rules may mean a smaller load, but you are protecting yourself and others working in your area.

2. Use a secured safety platform when lifting personnel. A forklift is built for only one rider—the operator. Because of the hazardous conditions that can result, it is unauthorized for anyone to ride the forks of a forklift or hitch a ride in any manner. If a forklift is used to elevate workers, a safety platform must be secured to the forks. The platform should be specially built and secured to keep it from slipping from the forks, and it should have a solid floor and handrail (fig. 8-25).

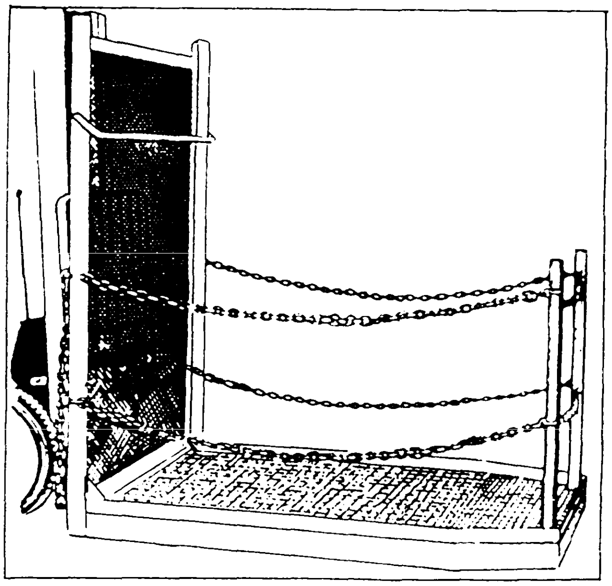


Figure 8-25.—Safety platform.

3. Keep arms and legs inside the operator's compartment. Holding them outside the machine can be dangerous in narrow aisles.

4. Keep yourself and all others clear of the hoisting mechanisms. NEVER PUT HANDS, ARMS, HEAD, OR LEGS THROUGH THE HOISTING MECHANISM. This rule applies to both you and the rigger. A rigger should not be near the load or hoisting mechanism while you are attempting to pick up, hoist, or deposit a load.

5. Never allow anyone under the load.

6. Report damaged or faulty equipment immediately—do not operate a forklift that is unsafe. You can complete a job with a forklift safely only when it is working correctly; therefore, a forklift should never be operated when it is not running properly.

7. Avoid bumps, holes, slick spots, and loose materials that may cause your forklift to swerve or tip over. Different models of forklifts are designed to operate under different conditions. Although large forklifts can adapt to more uneven ground, do not expect them to maintain their balance under abusive ground conditions. Try to pick the smoothest areas when moving material from one place to another.

8. Travel slowly in narrow aisles and around corners, especially blind corners. To help avoid collisions, you should sound your horn in advance.

9. Lower the carriage completely, and set the parking brake before leaving your forklift. Block the wheels when parking on an incline or working on the forklift. These rules apply under all conditions, even if you are only going to leave your forklift for a moment. A driverless forklift does not have to move far in close quarters to cause serious injury.

10. Do not turn on an incline. For stability, a forklift should not be driven along the side of an incline that leans the forklift sideways. Always keep either the rear end or front end of the forklift pointed up or down the slope.

11. Do not fill the fuel tank while the engine is running.

12. Sudden starts and stops cause premature wear on parts of the forklift, such as axles and gears, and cause tires to wear faster. Personnel nearby may become injured and materials may be damaged by a forklift suddenly going into motion or going out of control.

13. Because a forklift is designed to perform so many functions within a small space, you must anticipate certain clearance situations. As an operator, you must be aware the forks will sometimes protrude beyond the front of the load. Because of this, you may

strike objects or lift or nudge other loads on pallets. Many serious mishaps have been caused by uprights and overhead guards striking pipes and beams connected to the ceiling in a warehouse. Some forklift models steer from the rear axle. On these machines, the tail swings and can hurt personnel or damage property.

CAUTION

FAILURE TO KEEP A CAREFUL WATCH IN THE DIRECTION OF TRAVEL CAN RESULT IN DAMAGE TO SOMETHING OR INJURY TO SOMEONE.

CHAPTER 9

FRONT-END LOADERS, EXCAVATORS, AND DITCHERS

Front-end loaders, excavators, and ditchers are used to support construction operations anytime there is a need to lift, load, unload, clear, grub, excavate, or trench. A variety of makes and models of this equipment are used in the Navy and the Naval Construction Force (NCF). Each operator is responsible for reading the operator's manual to obtain detailed information about each make and model. his chapter covers the general characteristics and basic principles of operations of front-end loaders, excavators, and ditchers.

FRONT-END LOADERS

The front-end loader is a self-contained unit mounted on rubber tires or tracks and is one of the most versatile and capable pieces of equipment used in the NCF. The front-end loader can be equipped to operate as a loader, a dozer, a scraper, a clamshell, a forklift, a backhoe, a crane, an auger, or a sweeper.

RUBBER-TIRED FRONT-END LOADER

Mounted on large rubber tires, the front-end loader has a relatively low ground bearing pressure (approximately 45 pounds) that enables it to perform a large variety of jobs. The rubber-tired front-end loader (fig. 9-1) has three manually selected forward gear ranges that permits good mobility when traveling from one jobsite to another. The full power soft shift transmission allows the gear range and direction of travel changed at anytime without stopping the machine from maintaining a high rate of production. The large rubber tires provide good traction on unstable surfaces and allow the front-end loader to perform on side slopes of 15 percent and on front slopes up to 30 percent. The hydraulic system gives the operator positive control of the front-end loader attachments and steering system.

CRAWLER-MOUNTED FRONT-END LOADER

Mounted on crawler tracks, the crawler-mounted front-end loader has a low ground bearing pressure that

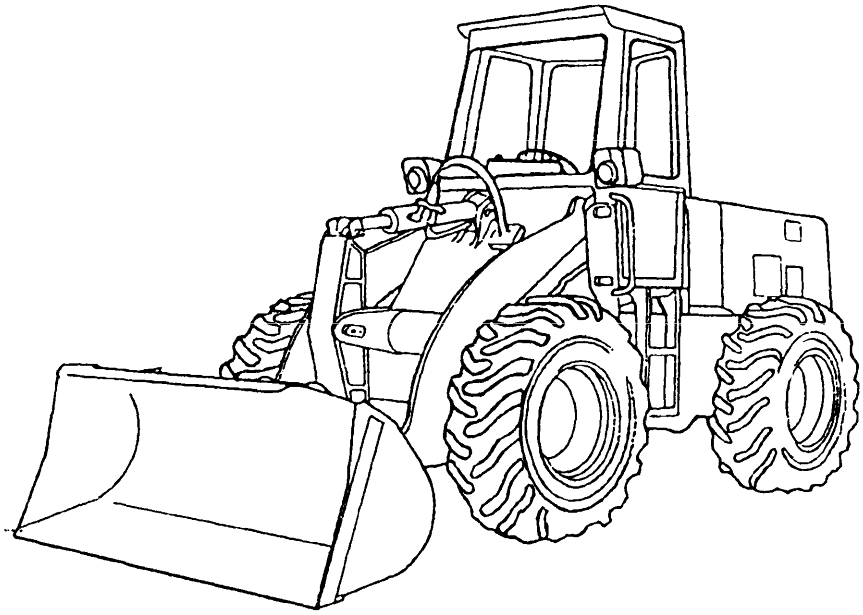


Figure 9-1.—Rubber-tired front-end loader.

enables it to operate in areas where wheeled front-end loaders cannot go. The crawler-mounted front-end loader (fig. 9-2) has a lower speed than a rubber-tired front-end loader, and this decreases its mobility; however, the crawler-mounted front-end loader can be operated on side slopes of up to 35 percent and on front slopes of up to 60 percent. The hydraulic system provides positive control of the front-end loader, and the crawler tracks are normally semi-grouser shoes (fig. 9-3) that permit it to work on firm ground with little damage to the surface.

ATTACHMENTS

Attachments contribute to the efficient performance of front-end loaders. Some loaders used in the NCF are procured with a bucket, forklift, and backhoe attachments (fig. 9-4). These attachments allow the front-end

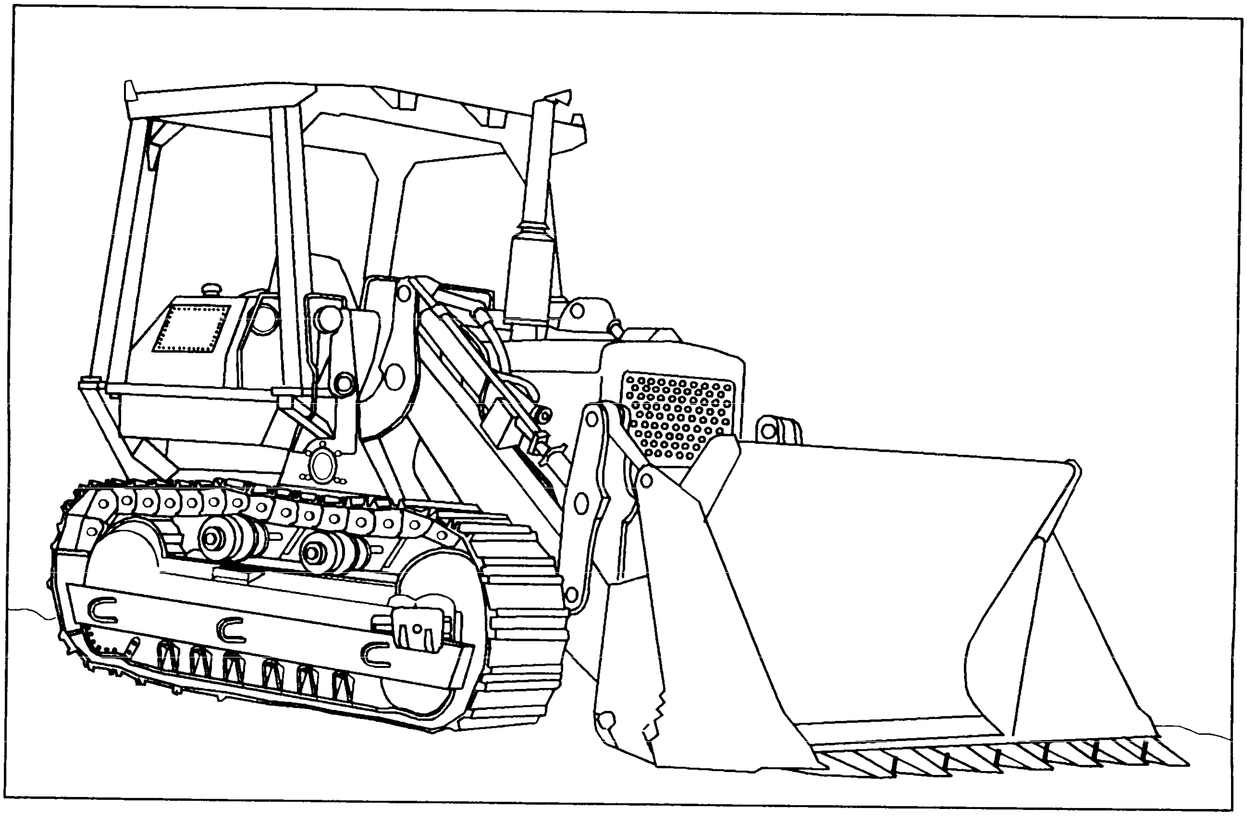


Figure 9-2.-Crawler-mounted front-end loader.

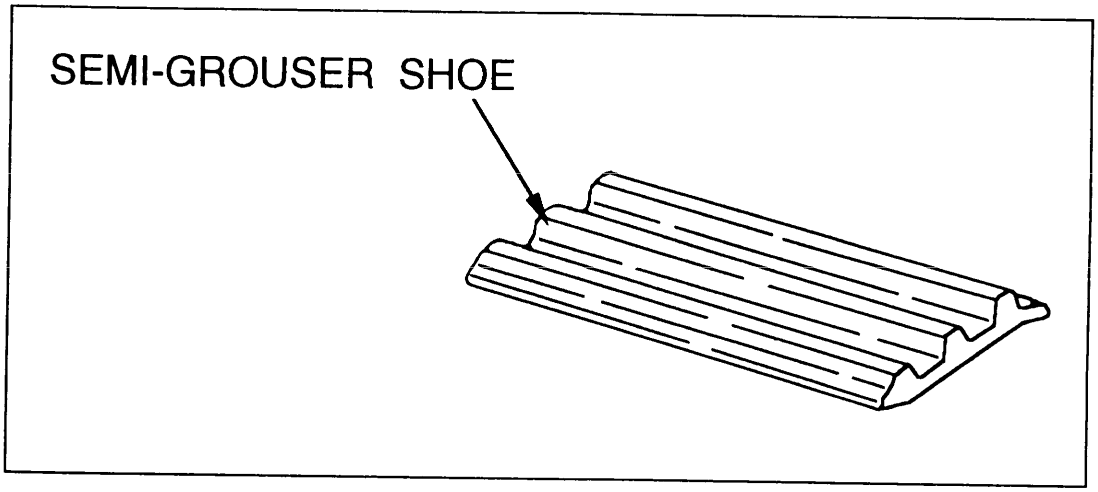


Figure 9-3.-Semi-grouser shoe.

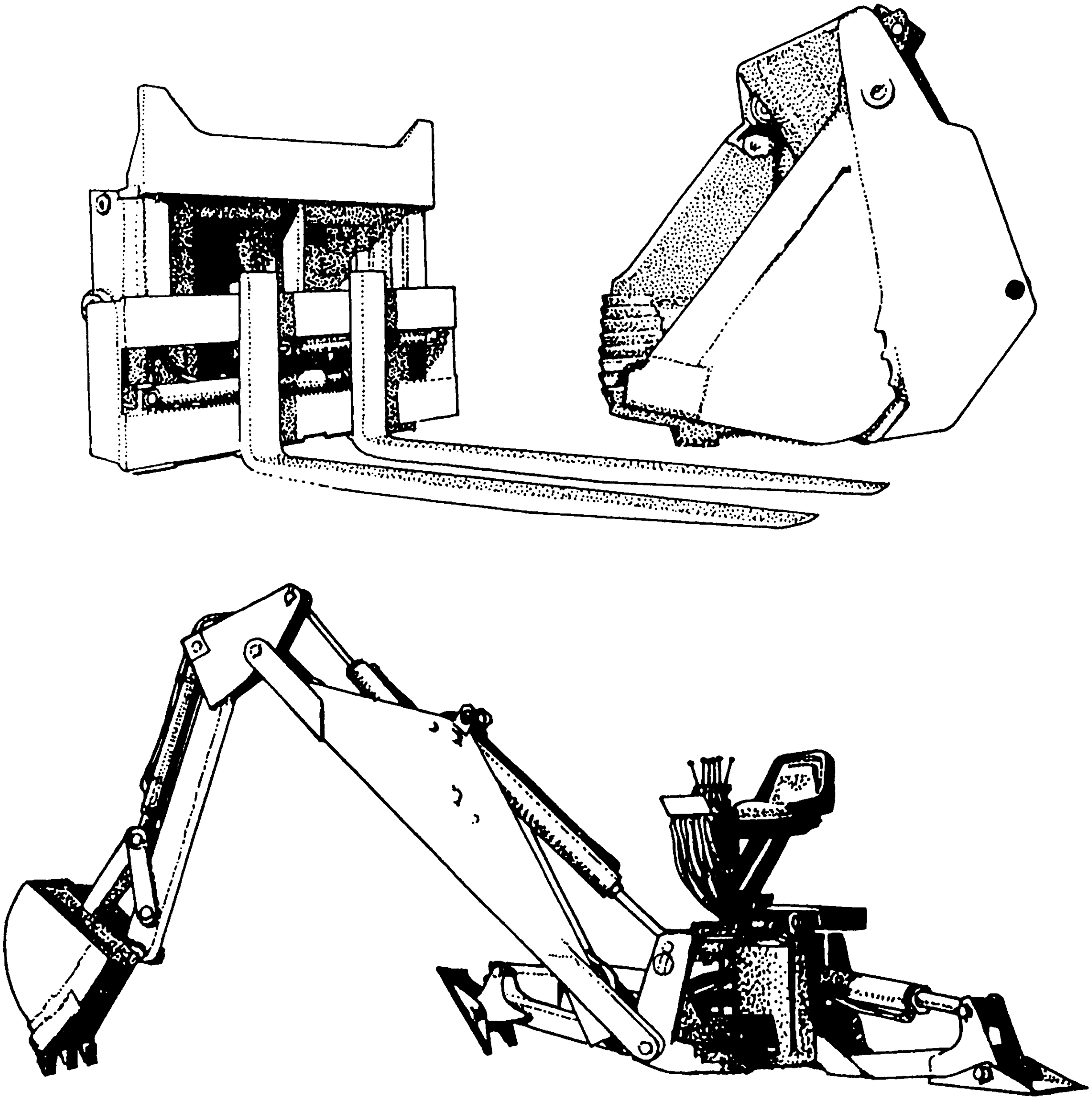


Figure 9-4.—Front-end loader attachments.

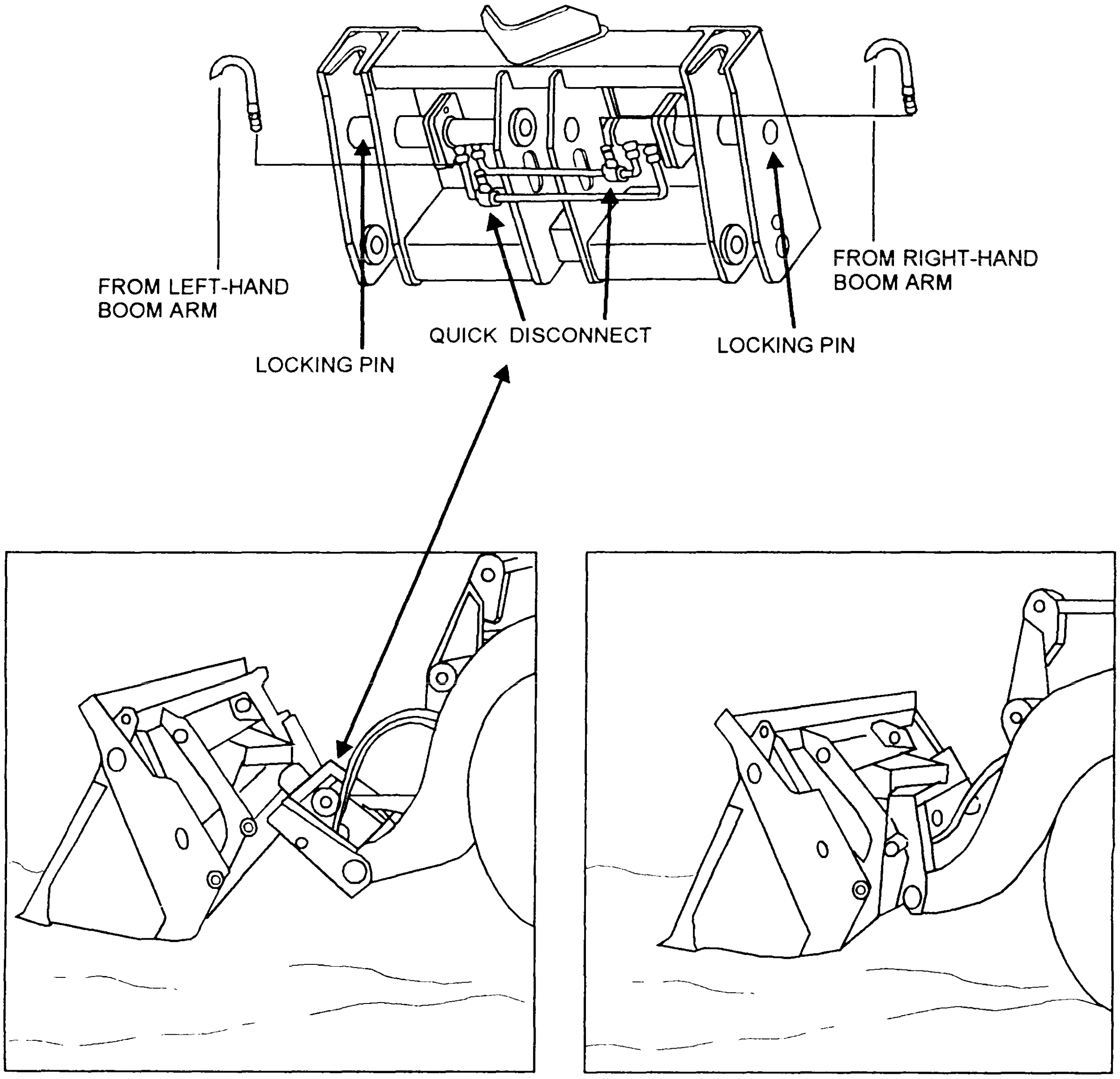


Figure 9-5.—Attachment connection.

loader to be an ideal piece of equipment for construction projects, saving the need for numerous pieces of equipment that can be used elsewhere.

Quick-disconnect hydraulic hose fittings and hydraulic controlled locking pins permit these attachments to be changed easily, as shown in figure 9-5.

Buckets

Two types of front-end loader buckets are commonly used: a general-purpose bucket (fig. 9-6) and a multi-segment (4-in-1) bucket, also known as a multipurpose (4-in-1) bucket (fig. 9-7). Both types may be equipped on crawler or rubber-tired wheeled loaders.

The **“general-purpose bucket”** is a single-piece bucket constructed of heavy-duty, all-welded steel with bolted or welded replaceable cutting edges. Also attached are bolt-on replaceable teeth (fig. 9-8) that allows the bucket to be used for excavation of medium-to-hard materials.

The **“multipurpose (4-in-1) bucket”** is also constructed of heavy-duty, all-welded steel with bolted or welded replaceable cutting edges. This bucket also has bolt-on replaceable teeth attached that provide for excavation of medium-to-hard materials. However, the multipurpose (4-in-1) bucket has a two-piece construction that makes it more versatile than the

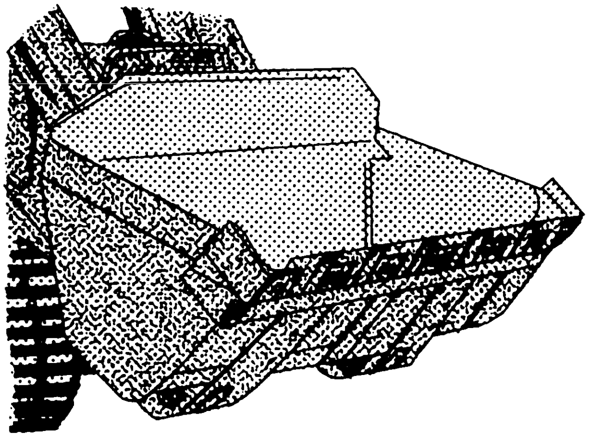


Figure 9-6.-General-purpose bucket.

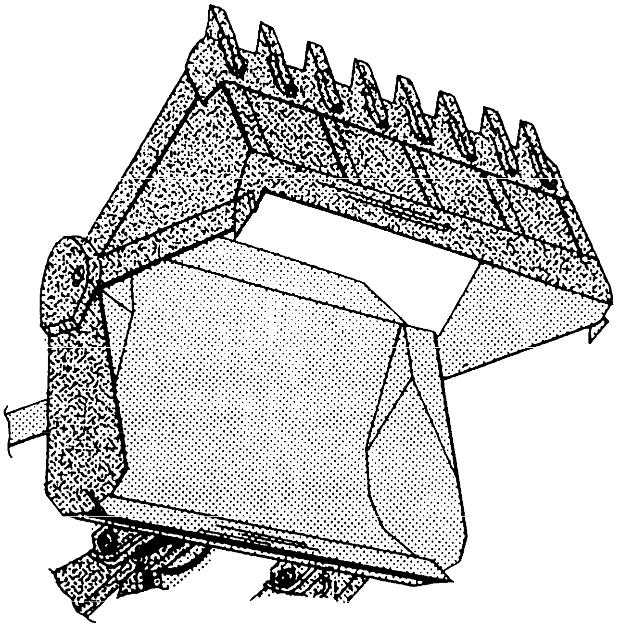


Figure 9-7.—Multipurpose (4-in-1) bucket.

general-purpose single-piece bucket. For example, the multipurpose (4-in-1) bucket can be used as a clamshell, a dozer, a scraper, or as a skid shovel.

Forklift

The forklift attachment is a useful tool at remote project sites for unloading building material. Care must be taken not to overload the loader when using the forklift attachment.

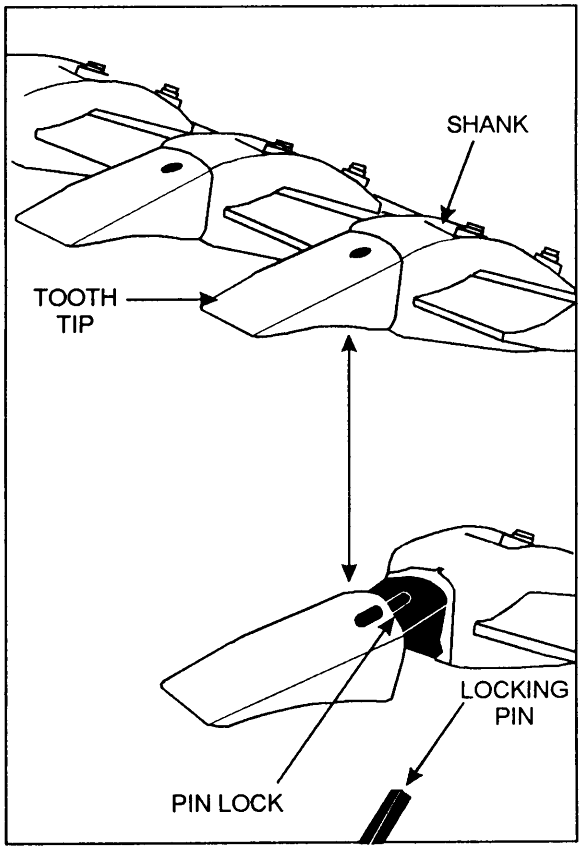


Figure 9-8.—Bucket teeth.

NOTE: A loader equipped with a forklift attachment must be operated using the same techniques of operation and safety rules designed for forklifts.

Backhoe

The backhoe attachment is a positive digging tool. It is used to dig below the ground, such as trenches, combat fighting positions, building footers, and foundations.

The backhoe is attached to the loader frame with a ridged coupling. The hydraulics use a quick-disconnect coupling to tap the loader hydraulic system for a power source.

OPERATING TECHNIQUES

When operating a loader equipped with a skid bucket, keep the engine speed at full throttle and operate in the first or second gear transmission range. Use second and third gear for traveling.

Start all jobs from nearly level ground if possible. When necessary, level an area large enough to provide

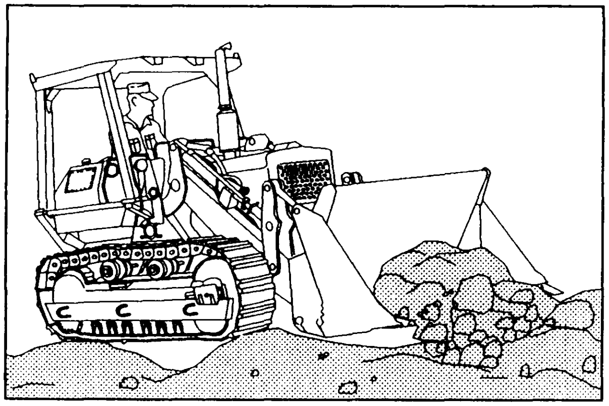


Figure 9-9.—Up-and-down pitching of a loader on irregular terrain.

sufficient working space for the loader. This step prevents up-and-down pitching of the loader (fig. 9-9) and results in a smoother digging operation.

Track and wheel spinning should be avoided, because loader tires are expensive and excessive spinning of the tires while loading causes premature wear and tear. Additionally, it converts a smooth working area into ruts that pitch and tilt the loader. A smooth working area is safer and more comfortable. It also puts less wear and tear on the machine and yourself; therefore, production is increased.

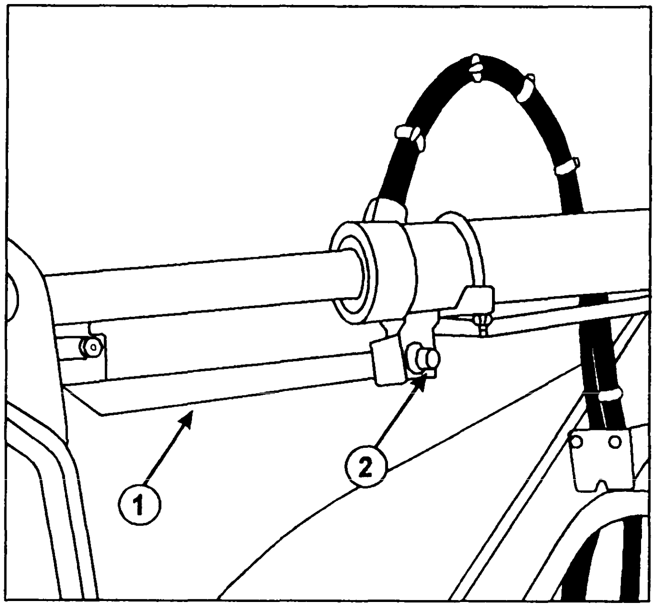
Cross ditches, ridges, rocks, or logs slowly and, if possible, at an angle. This procedure slows the fall, lessens the danger of upsetting the loader, and reduces the jolt of the fall that can harm both the operator and the loader.

A uniform system of hand signals must be used in all front-end loader operations. While the authority for giving signals must be assigned to only one person under normal working conditions, the responsibility for giving an emergency stop signal belongs to anyone in the vicinity who believes such a signal is necessary. The person giving the signals must be clearly visible to the operator at all times. Hand signals used in front-end loader operations are shown in appendix IV.

NOTE: You must recognize and understand these signals when operating equipment. Additionally, you must also be able to give them when called on to act as a signalman during any equipment operation.

Automatic Bucket Leveler

Most 515 B series dresser rubber-tired front-end loaders used in the NCF have an automatic bucket leveler located on the underside of the bucket cylinder (fig. 9-10).



1. TRIP BAR
2. PROXIMITY SWITCH

Figure 9-10.—Automatic bucket leveler.

The automatic bucket leveler is preset to stop the bucket in a horizontal or digging position. A trip bar (1) is attached to and moves with the cylinder rod. The proximity switch (2) creates a magnetic field circuit that is completed by the proximity of the trip bar within the magnetic field. Once the bucket is dumped, place the bucket lever in the bucket "rollback" position. When the bucket reaches its preset position, the trip bar moves out of the magnetic field circuit created by the proximity switch and automatically stops. Then the bucket control lever returns to the "hold" position.

NOTE: Refer to the manufacturer operator's manual when the automatic bucket leveler needs adjustment.

Position Indicator

The general-purpose bucket shown in figure 9-6 is normally used as a skid shovel. The multipurpose bucket shown in figure 9-7 serves as a skid shovel, but can also be used as a bulldozer, scraper, and clamshell.

Most front-end loaders are equipped with six bucket control lever positions, such as **raise, hold, lower, float dump, and rollback.** Dump and rollback can be used

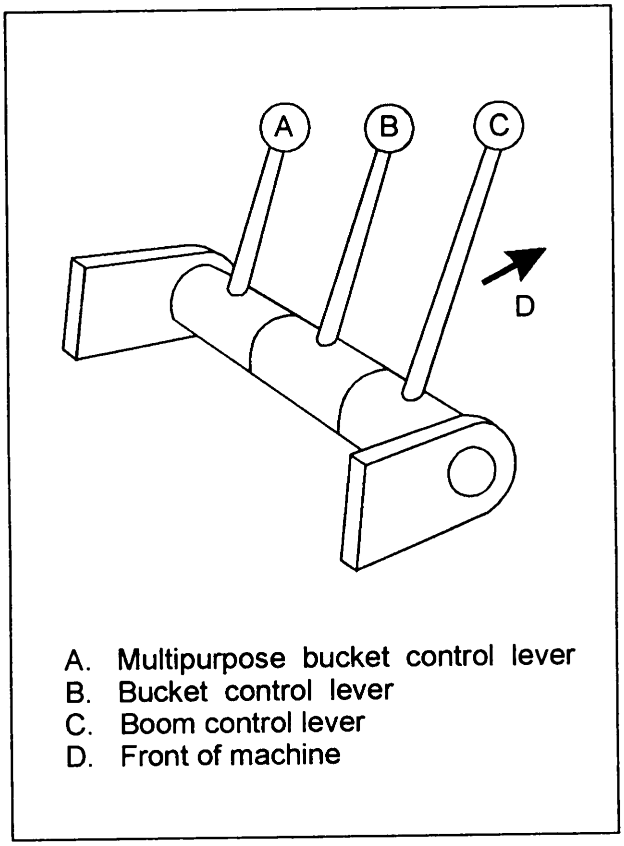

A
B
C
D
A. Multipurpose bucket control lever
B. Bucket control lever
C. Boom control lever
D. Front of machine

Figure 9-11.—Control levers.

at the same time with any other four positions. Also, most loaders have a position indicator and depth gauge indicator mounted on the bucket.

To set the multipurpose attachment as a bucket, the operator pulls the control lever back (fig. 9-11) until the clamshell indicator is at the "O" setting on the clam product graphic (fig. 9-12).

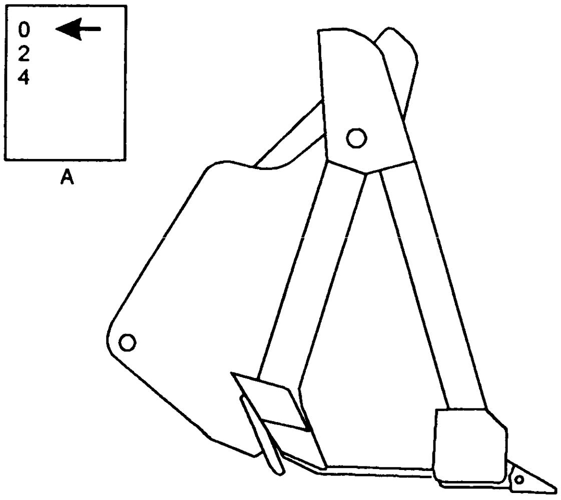


Figure 9-12.—Multiltipurpose bucket set in "bucket" position.

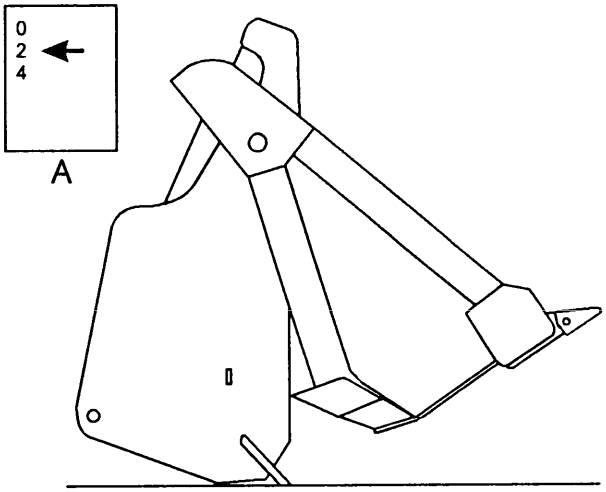


Figure 9-13.—Multipurpose bucket set in "scraper" position.

To set the multipurpose bucket as a scraper, you open the clamshell until the indicator points to 2 or 4 on the clam product graphic (fig. 9-13). The more the clamshell is open, the deeper a cut can be made.

To use the multipurpose bucket as a dozer, you open the clamshell until the clamshell indicator is at the bottom of the clam product graphic (fig. 9-14).

When using the multipurpose blade as a dozer, you can adjust the amount of cut by the pitch of the dozer

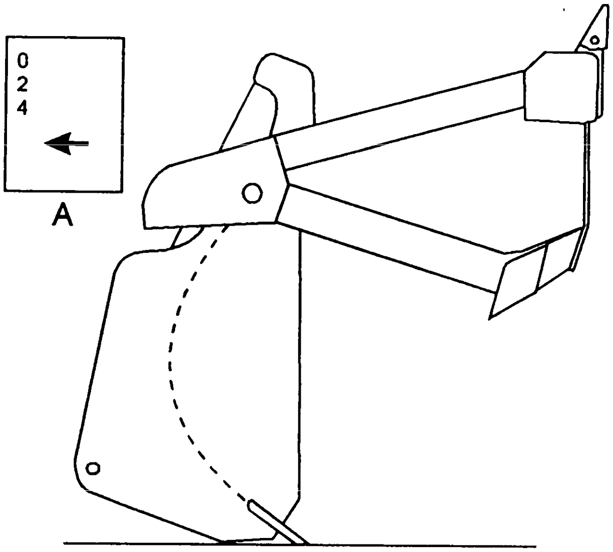


Figure 9-14.—Multipurpose bucket set in "dozer" position.

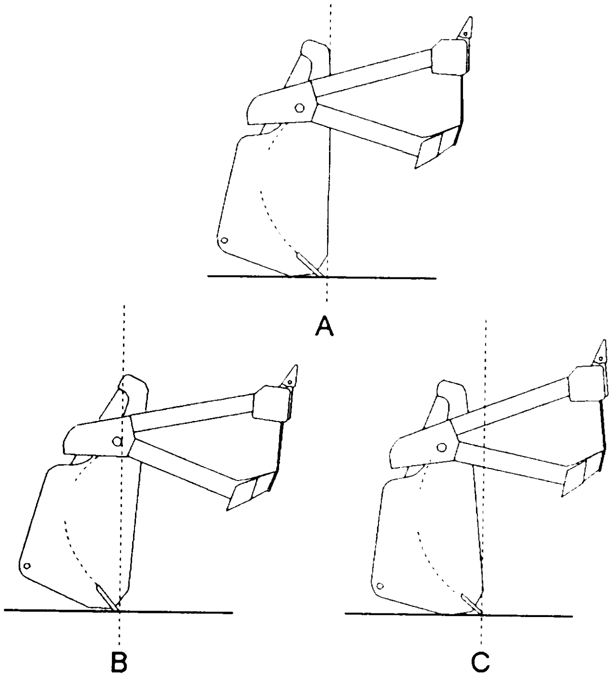


Figure 9-15.—Dozer blade tilt positions.

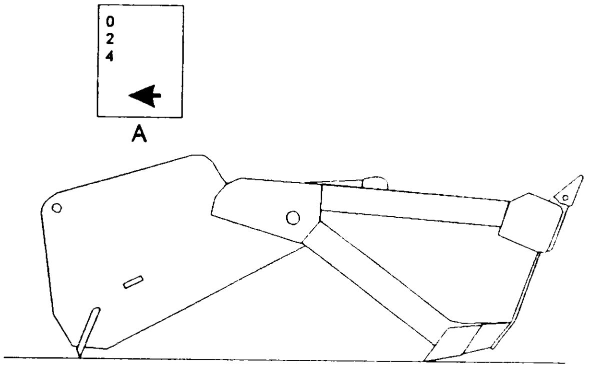


Figure 9-16.—Multipurpose bucket set in "clamshell" position.

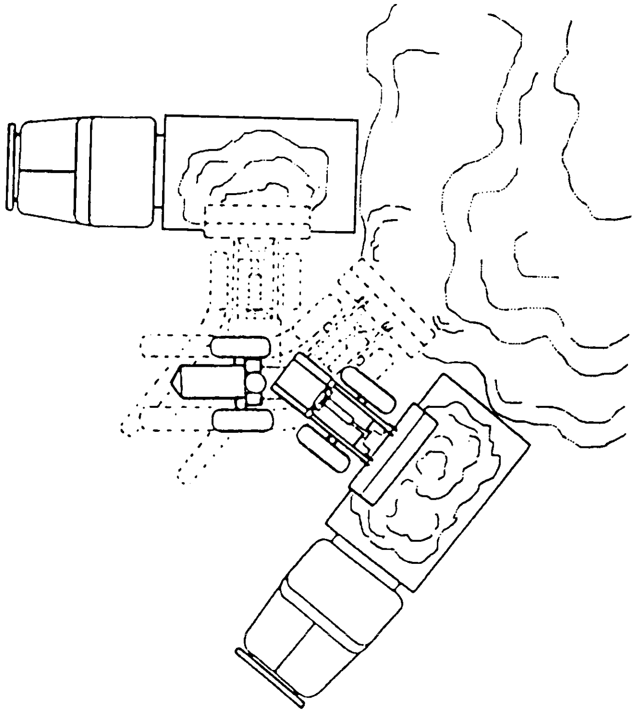


Figure 9-18.—"V" method of loading.

blade. This is done by tilting the blade forward or backward, as shown in figure 9-15.

To use the multipurpose bucket as a clamshell, you open the clamshell until the clamshell indicator is at the bottom (fig. 9-16). Then you tilt the bucket forward all the way.

NOTE: Multipurpose bucket position indicators differ, depending on the manufacturer. Read the operator's manual for the type loader you are assigned to operate.

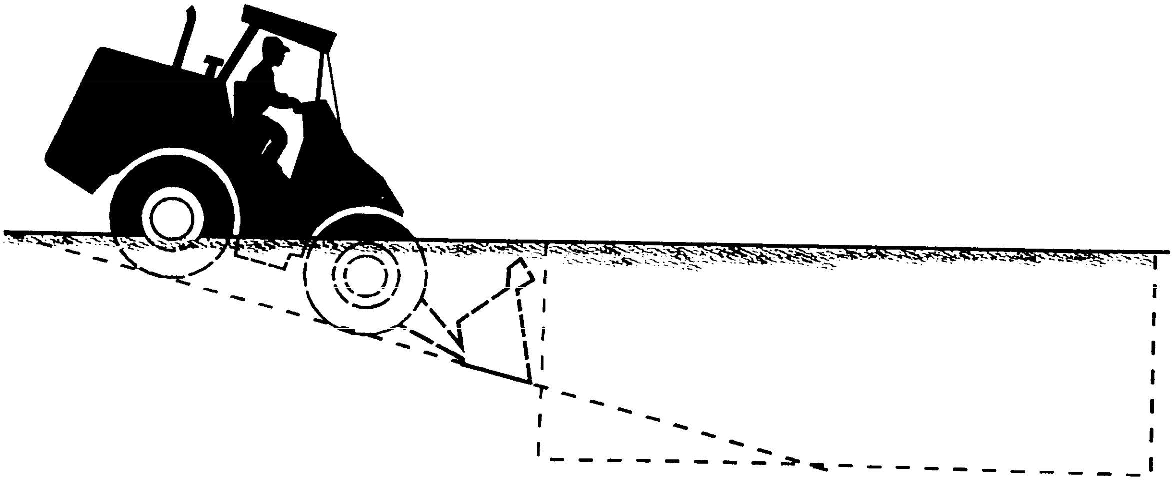


Figure 9-17.—Ramp construction for belowground excavation.

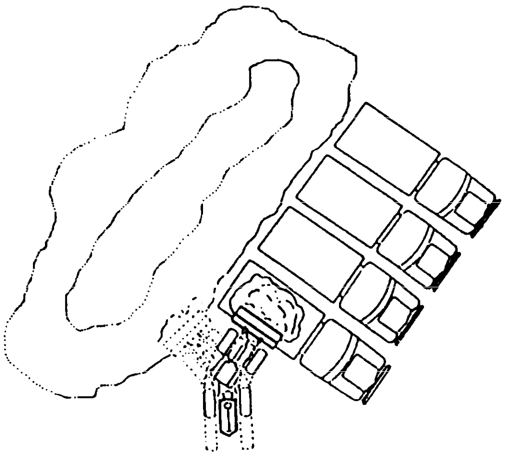


Figure 9-19.-Step-loading method.

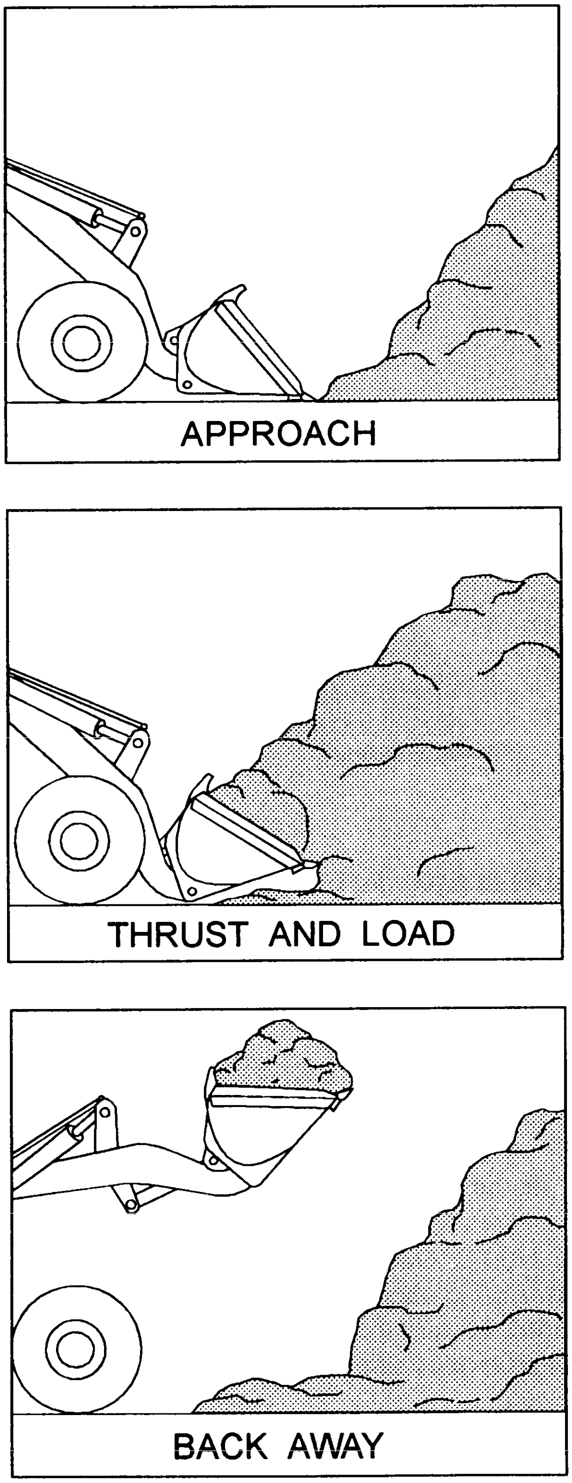


Figure 9-20.—Bucket-loading technique.

Loader Operation

A front-end loader can dig excavations, such as building foundations and other belowground areas, if the material to be excavated is not too hard. Belowground operations require construction of a ramp into the excavation to bring the material out (fig. 9-17). The slope of the ramp depends on the type of loader operated; for example, a crawler-mounted loader may dig a more abrupt approach to the excavation.

When loading from a bank or stockpile, use the "V" method shown in figure 9-18 or the step-loading method shown in figure 9-19. Position the dump truck at about a 30-degree to a 45-degree angle from the stockpile. Additionally, when possible, load the dump truck downwind to prevent dirt and dust from blowing back into your face. Keep the truck close to the work area to minimize loader travel, and keep the work area clean and level.

The bucket is loaded by moving the loader forward with the bucket at the desired digging level and with the engine at full-governed speed. As the bucket penetrates the material, raise the bucket slightly. When the material fills to the top of the spill board, roll the bucket all the way back (fig. 9-20). The rollback position is maintained to prevent spillage while backing away.

When transporting material, raise the lift arm to give the bucket the same ground clearance as provided by the loader axle. Keep the travel speed reasonable for safe operation. Upon reaching the truck, raise the bucket high enough to clear the truck body. Reduce forward speed and dump the load in the center of the dump bed, as

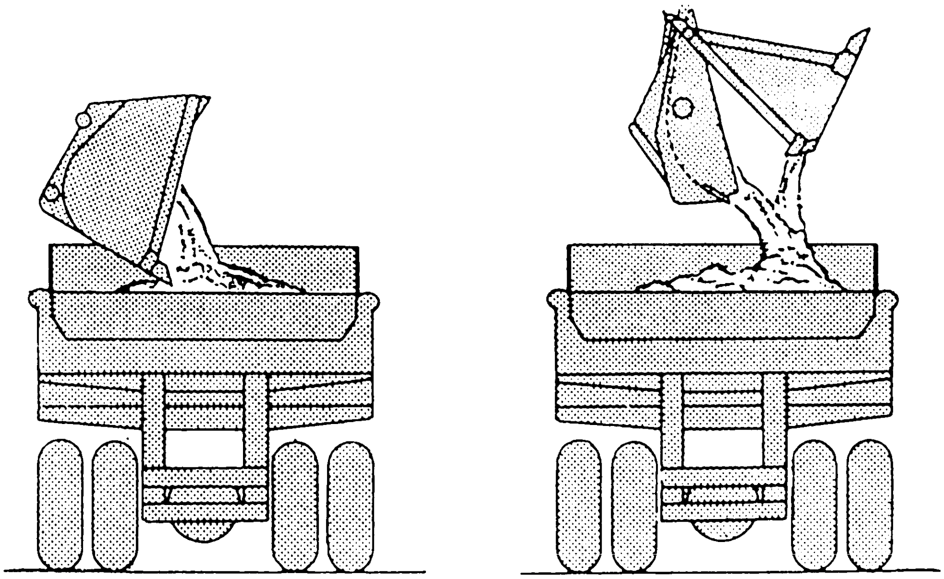


Figure 9-21.—Loading the dump truck.

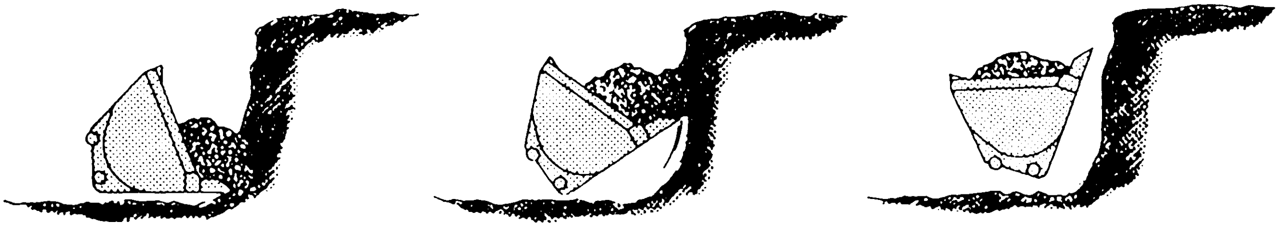


Figure 9-22.—Bucket positioned for filling from a bank.

shown in figure 9-21. Shake the bucket to loosen dirt from within. After the load is dumped, back away, lower the bucket to the carrying position, and return to the digging area.

CAUTION

A loaded bucket must never be transported in the fully raised position.

NOTE: Dump trucks should be loaded from the driver's side whenever possible. When the truck is being loaded, be sure the driver either stays in the cab (on cab-protected trucks) or away from the truck and loader.

When loading from a bank, keep the cutting edge flat, as shown in figure 9-22. Tilting the bucket back too far forces the flat of the cutting edge against the bank, preventing the bucket from digging. This maneuver is nonproductive and causes waste of power, time, and possible damage to the bucket cylinders and linkage.

When stockpiling material, move each load only once and keep the travel distance short. When possible, locate stockpiles as close to the jobsite as possible without hindering other work on the jobsite.

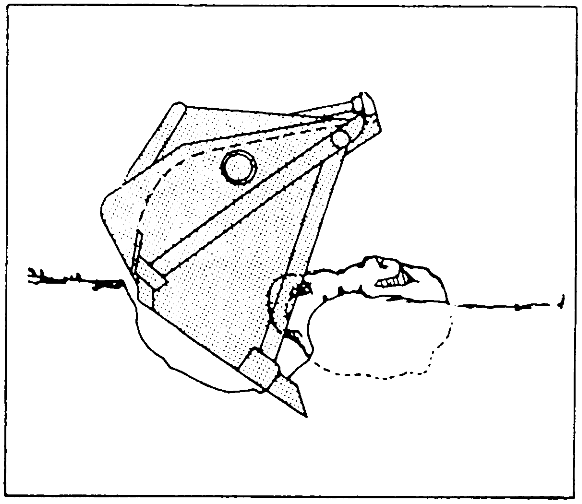


Figure 9-23.—Bucket positioned for clearing rocks or other solid objects.

When clearing a rocky area, remove the small and loose rocks first. Large rocks and other solid objects can then be loosened and moved easier.

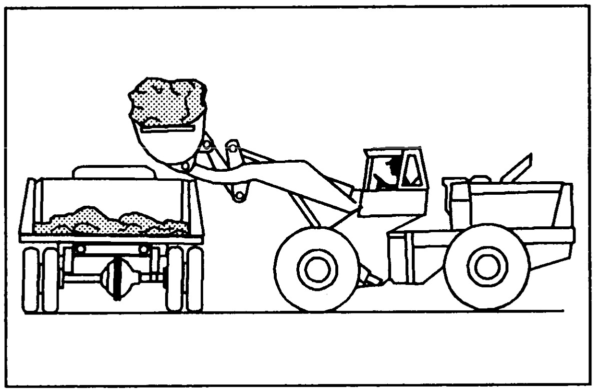


Figure 9-24.—Loading large rocks.

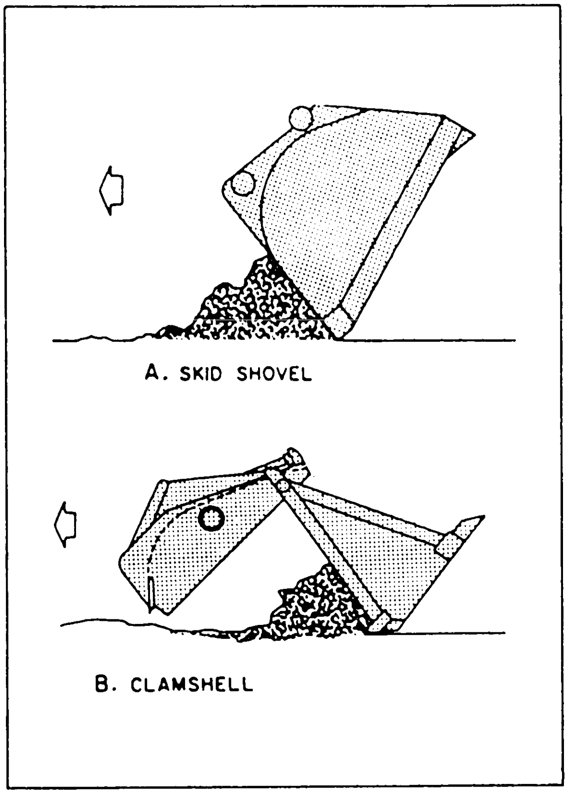


Figure 9-25.-Bucket positioned for back dragging nonsolid materials.

When loosening large rocks or other solid objects, you can get greater force and penetration by digging under the rock with the bucket, as shown in figure 9-23. Lifting the rock with the bucket while pushing increases traction and reduces track or wheel spinning.

When loading large rocks into dump trucks, place a load of dirt or sand into the dump bed. This material acts as a cushioning material and helps protect the dump bed from damage. Then load the large rocks into the center of the dump bed from the lowest possible height (fig. 9-24).

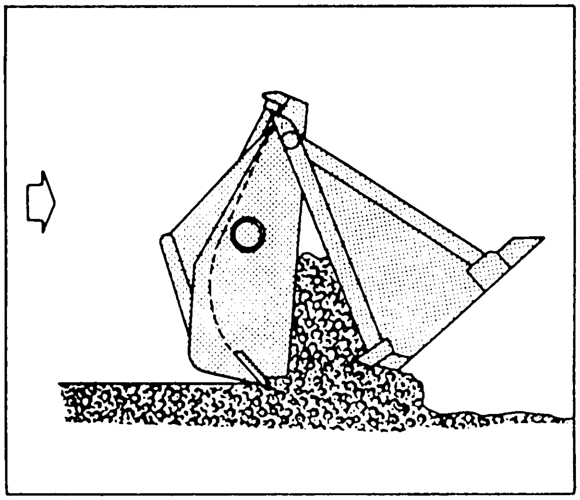


Figure 9-26.—Bucket clamshell positioned for spreading material.

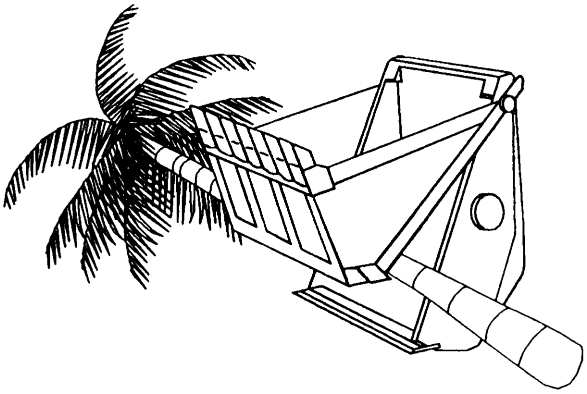


Figure 9-27.—Bucket clamshell positioned for loading trees.

NOTE: When you have extended tasking to haul large rocks or riprap, you should have the dump beds lined with wooden planking. This will save time loading sand or dirt and also protect the bed.

When finishing by back dragging in nonsolid materials, position the bucket, as shown in figure 9-25, views A or B.

NOTE: Back dragging abrasive materials causes premature wear to the bucket.

By placing the bucket in the scraper position and opening the clamshell slightly, you can spread material on the run. The amount of spread can be controlled by the size of the opening of the clamshell, as shown in figure 9-26.

When transporting trees or other large objects, always balance the load, as shown in figure 9-27.

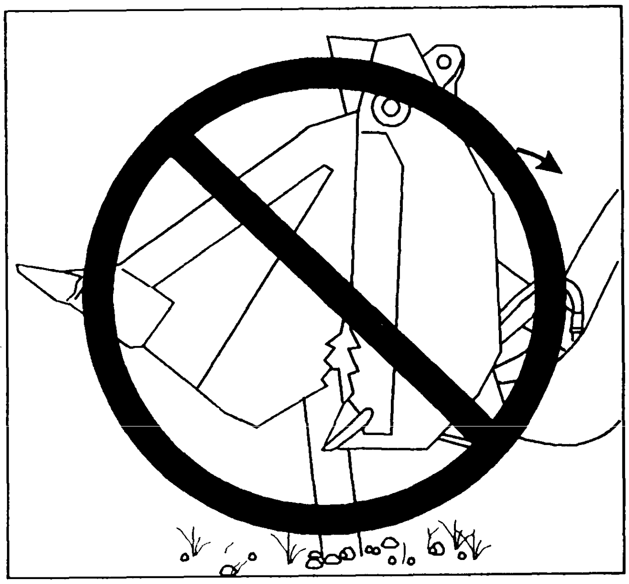


Figure 9-28.—Removing buried objects using the clamshell by rolling back the bucket.

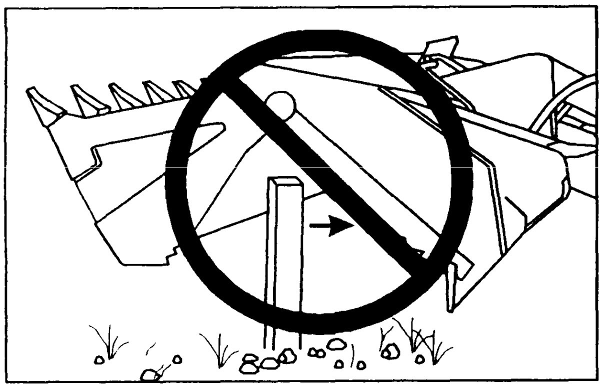


Figure 9-29.—Breaking off an object using the clamshell by back dragging.

Balance the load when picking it up to prevent twisting the boom assembly and linkage. When dumping awkward loads, dump slowly to reduce the shock of weight transfer to the rear axle when the bucket is emptied.

Improper Uses of the Multipurpose Bucket

Equipment Operators have created techniques to perform a variety of construction operations using loaders equipped with the multipurpose (4-in-1) bucket.

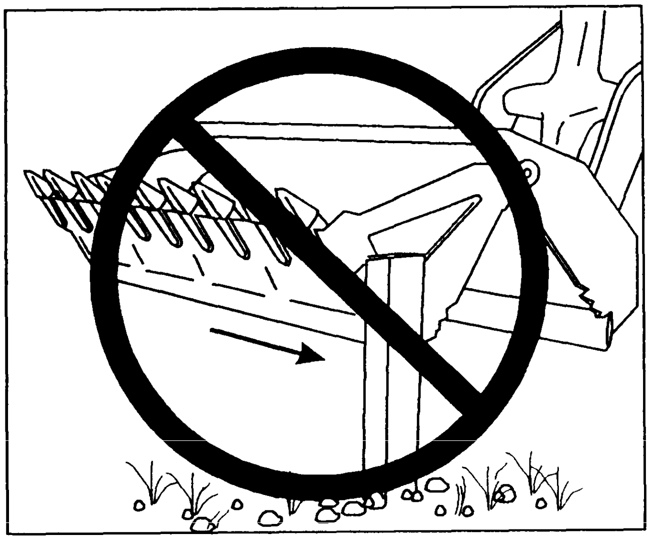


Figure 9-30.-Breaking off an object by side loading the clamshell.

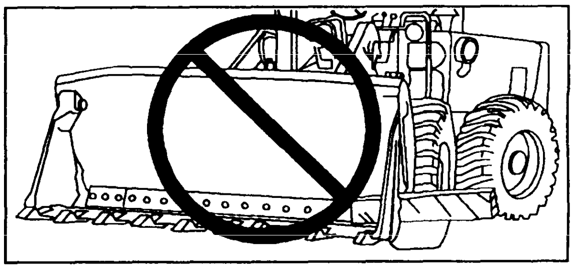


Figure 9-31.-Clamping an object on only one side of the clamshell.

However, these techniques can cause **UNNECESSARY DAMAGE** to multipurpose (4-in-1) buckets by subjecting them to conditions they were not designed for. Some of the ways a multipurpose bucket should **NOT** be used are as follows:

Do NOT use the rollback as a force to pull stumps or buried objects from the ground, because this may bend the clamshell (fig. 9-28).

Do NOT attempt to break off buried or anchored objects with the clamshell by back dragging, because this may bend the clamshell (fig. 9-29).

Do NOT attempt to break off buried or anchored objects by side loading the clamshell, especially when opened, because this may bend the sides of the clamshell (fig. 9-30).

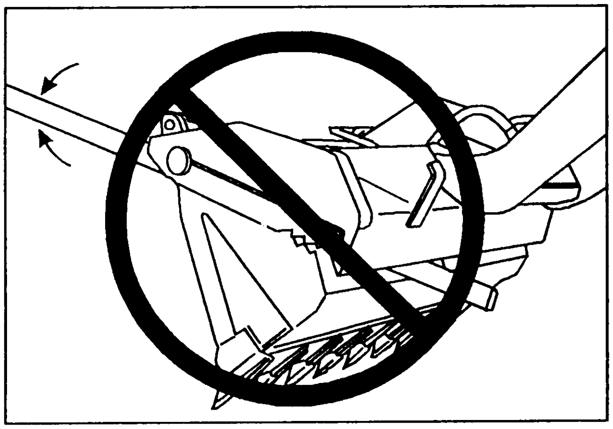


Figure 9-32.-Clamping an object and using it as a battering

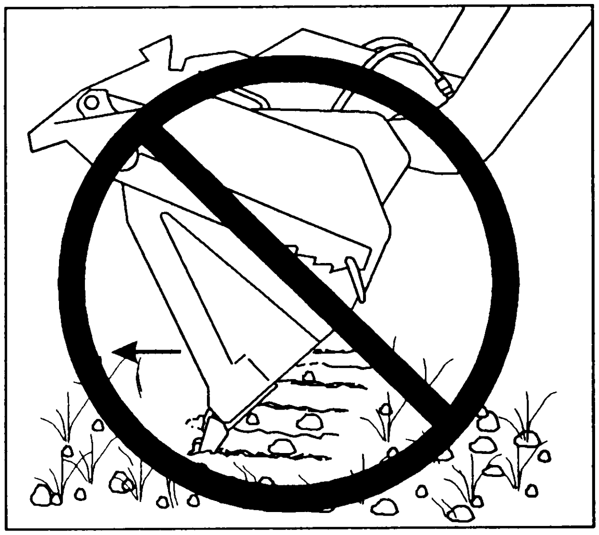


Figure 9-33.-Grading with the bucket in the dump position.

Do NOT clamp objects on only one side of the clamshell, because this causes uneven stresses and may twist the clamshell out of alignment (fig. 9-31).

Do NOT clamp objects and use them as battering rams, because this may bend the clamshell and the cutting edge (fig. 9-32).

Do NOT grade in the forward direction with the bucket in the dump position, because this can cause damage to the tilt cylinder and linkage (fig. 9-33).

Do NOT use the bottom of the clamshell as a pile driver, because this will bend the clamshell (fig. 9-34).

Do NOT attempt to load material in the bucket with an object caught between the clamshell and blade, because this could twist the clamshell out of alignment (fig. 9-35).

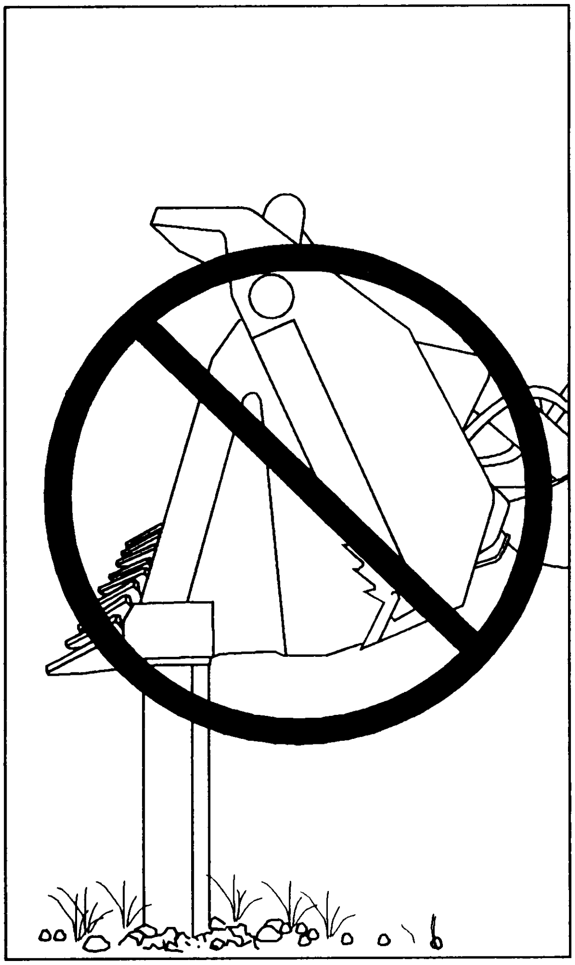


Figure 9-34.-Using the bottom of the clamshell as a pile driver.

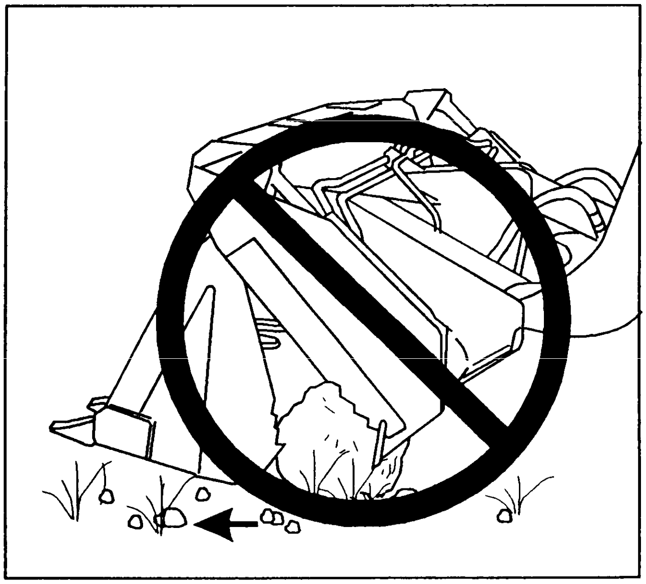


Figure 9-35.—Attempting to load material with an object caught in the clamshell.

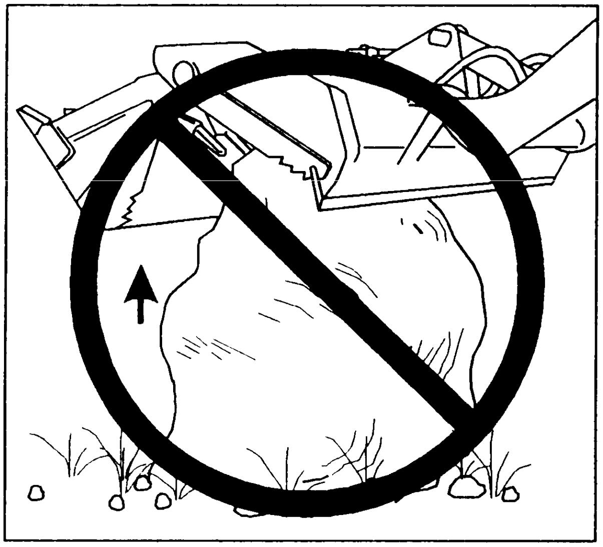


Figure 9-36.-Attempting to pickup objects too large for the clamshell.

Do NOT attempt to clamshell objects too large to handle, because this may damage both the bucket and linkage (fig. 9-36).

BACKHOE OPERATIONS

The backhoe attachment shown in figure 9-37 is used to dig hard material because of the positive pressure created by the hydraulic system. Its digging depth is limited by the length of the boom and dipper stick. The backhoe dumps the material into trucks to be hauled away or into piles alongside the excavation to be used as backfill material. Its dumping range is also limited to the length of the boom and dipper stick.

515 Dresser Backhoe

The 515 dresser backhoe attachment couples easily to the front of the loader frame, using hydraulic controlled pins and quick- disconnect hydraulic fittings. The procedure for setting up the backhoe attached to the 515 dresser is as follows:

1. After the backhoe has been coupled to the front of the front-end loader, raise the boom arm until the

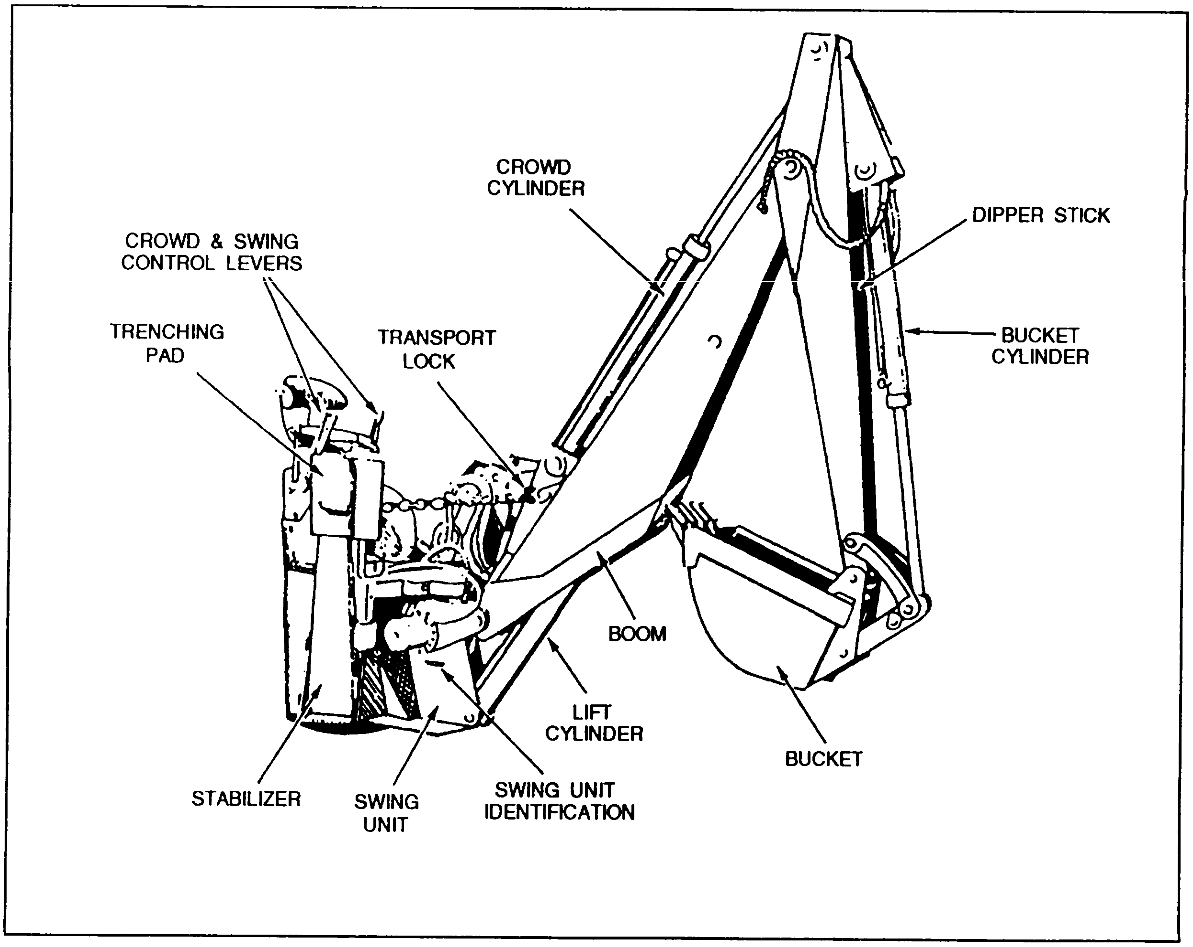

CROWD CYLINDER
CROWD & SWING CONTROL LEVERS
DIPPER STICK
TRENCHING PAD
TRANSPORT LOCK
BUCKET CYLINDER
BOOM
LIFT CYLINDER
BUCKET
STABILIZER
SWING UNIT
SWING UNIT IDENTIFICATION

Figure 9-37.-Backhoe attachment.

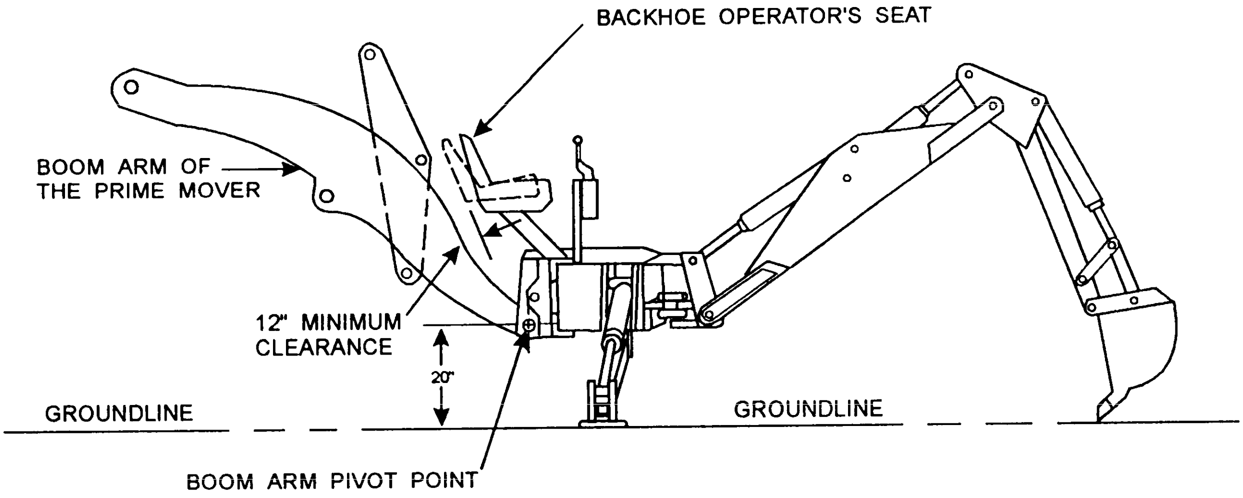

BACKHOE OPERATOR'S SEAT
BOOM ARM OF THE PRIME MOVER
12" MINIMUM CLEARANCE
20"
GROUNDLINE
GROUNDLINE
BOOM ARM PIVOT POINT

Figure 9-38.-Backhoe boom arm pivot point.

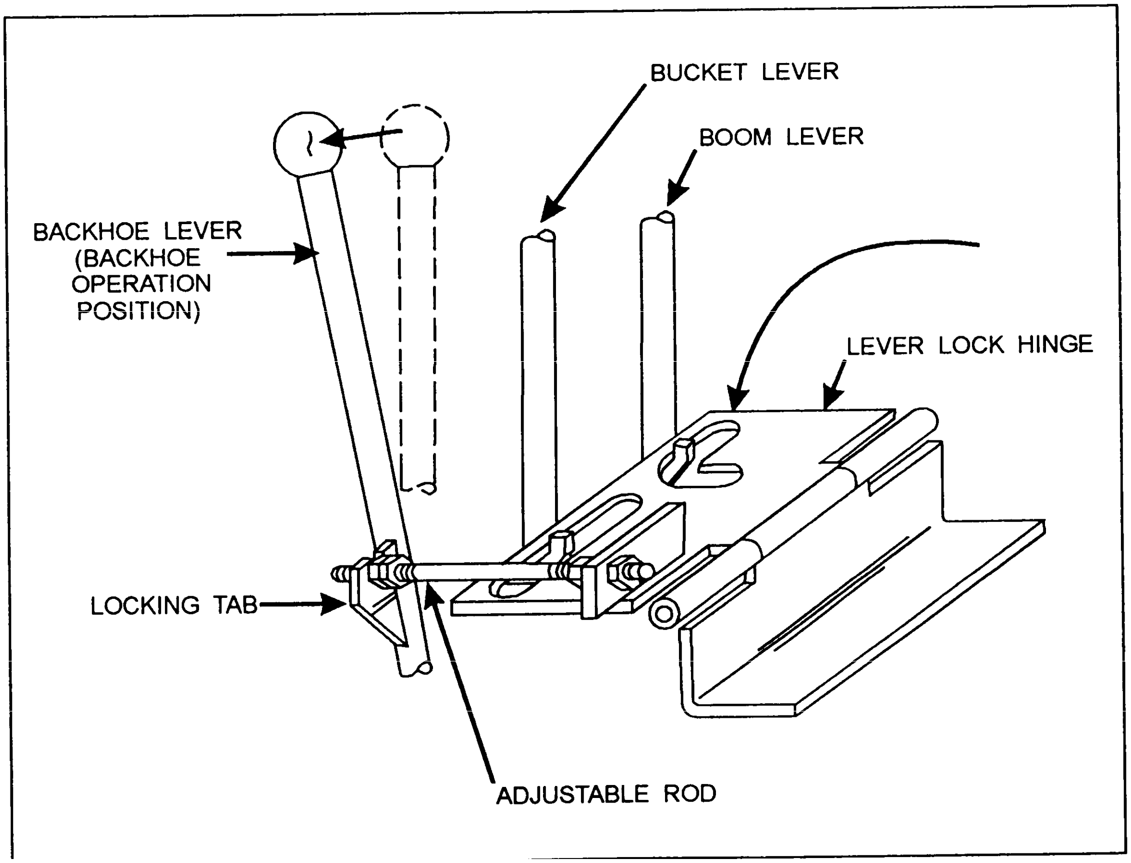

BUCKET LEVER
BOOM LEVER
BACKHOE LEVER (BACKHOE OPERATION POSITION)
LEVER LOCK HINGE
LOCKING TAB
ADJUSTABLE ROD

Figure 9-39.—Backhoe operation locking lever locking plate.

boom arm pivot point is approximately 20 inches from the ground, as shown in figure 9-38.

2. Using the bucket control lever, tilt the backhoe main frame until the top of the main frame is parallel with the ground.

3. For backhoe operations, place the two levers fiut.best from the operator in the hold position. Place the lever closest to the operator in the forward position. Move the locking plate in the position shown in figure 9-39, locking the lever in the forward position and the two other levers in the hold position.

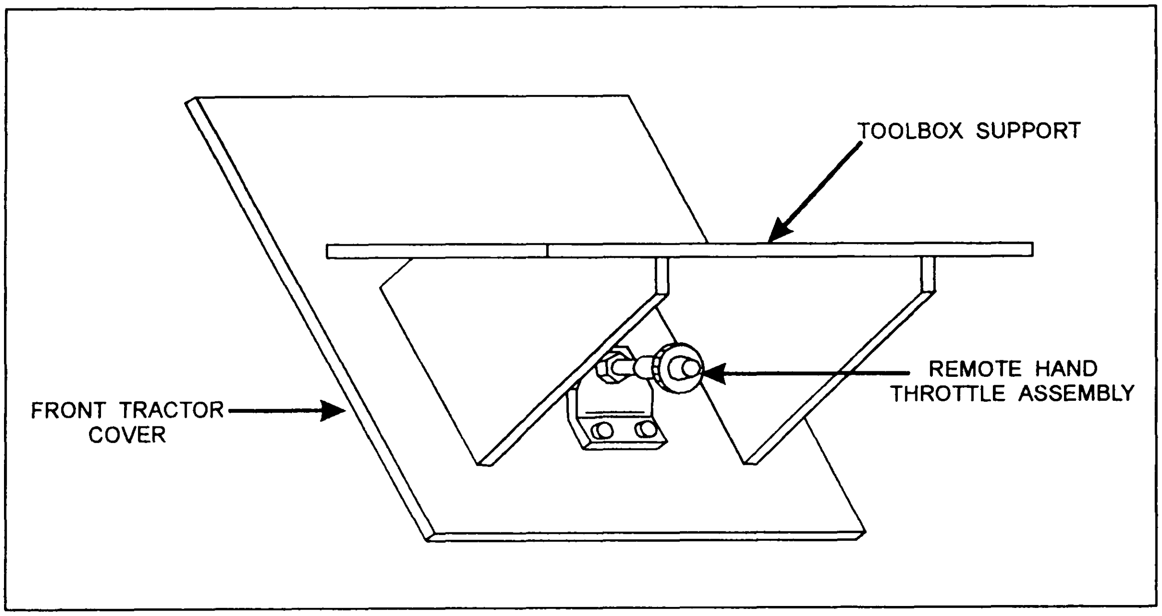


Figure 9-40.—Remote hand throttle assembly.

4. The loader is equipped with a remote hand throttle assembly (fig. 9-40) located on the front cover of the loader, which is behind the backhoe operator's seat. The hand throttle is preset to the backhoe specifications to deliver the proper amount of hydraulic oil flow for backhoe operations. The speed of the engine determines the volume of hydraulic oil delivered to the backhoe and the speed of the cylinder movements. Because of this, you should set the engine at a low speed until you are familiar with the control lever pattern.

NOTE: The backhoe is designed to operate efficiently at a preset gallons per minute flow of hydraulic fluid. Setting the engine throttle in excess of that set for backhoe operations creates excessive hydraulic temperatures and pressures that can damage hydraulic and structural components.

5. Lower the backhoe stabilizer legs to fix the backhoe in position.

6. Warm up the backhoe hydraulic system by extending and retracting each hydraulic cylinder piston rod several times to circulate warm oil through the hydraulic system. When the backhoe hoses feel warm when touched, the backhoe is ready for operation.

WARNING

Before performing maintenance on the backhoe, you must extend the dipper stick fully and set the bucket and stabilizer on the ground. Shut down the engine, and actuate all of the control levers back and forth to relieve the hydraulic pressure in the system.

Loader Backhoe

The loader backhoe tractor (fig. 9-41) is equipped with a 1.3-cubic-yard bucket mounted on the front and the backhoe mounted on the rear.

The loader is equipped with a four-speed transaxle that permits the gears to be shifted from first or second to third or fourth and back again to third without stopping. When shifting gears, always make sure the engine speed remains in the green area of the tachometer.

The loader also has a differential lock that gives equal power to both rear wheels when the machine is stuck or before the loader is operated through a soft or muddy area. When the loader is stuck, the differential lock is actuated as follows:

1. Make sure the rear wheels are not turning.
2. Push down the clutch cutout pedal (fig. 9-42).
3. Push down the differential lock pedal.
4. Release the clutch cutout pedal.
5. Increase the engine speed and release the differential lock pedal.

NOTE: The differential lock releases automatically when the load is removed.

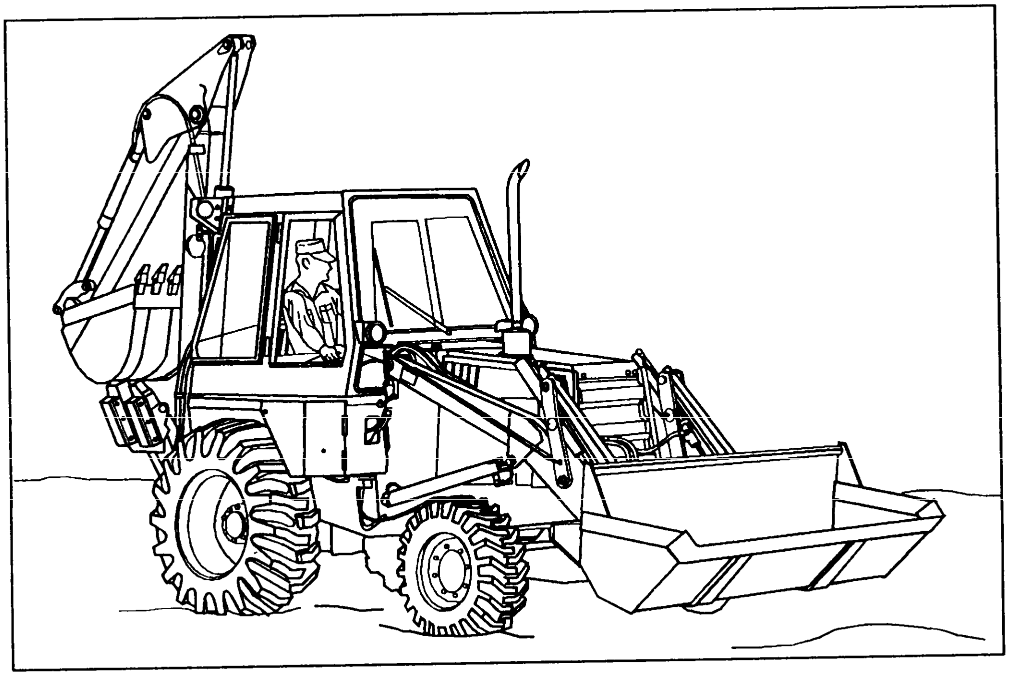


Figure 9-41.—Loader backhoe.

Before operating through a soft or muddy area, you can actuate the differential lock as follows:

1. Before moving the loader through an area that is soft or muddy, make sure that the loader is moving in a straight direction and that one of the rear wheels is not rotating faster than the other rear wheel.

2. Push down the differential lock pedal while the loader is moving through the soft or muddy area.

3. After the loader has moved through the area, release the differential lock pedal.

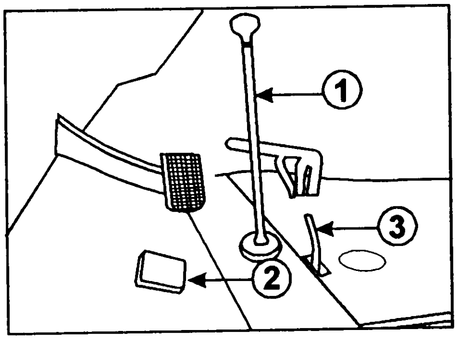
NOTE: Engaging the differential lock when the loader is turning or if one rear wheel is rotating faster than the other wheel can cause damage to the transaxle.

When servicing the engine with the loader lift arms raised, always use the support strut (fig. 9-43).

The procedure for attaching the support strut is as follows:

1. Empty the loader bucket and raise the loader lift arms to the maximum height and stop the engine.

2. Remove the rear pin from the support strut and lower the strut onto the cylinder rod.



1. Four speed transaxle control
2. Clutch cutout pedal
3. Differential lock

Figure 9-42.—Transaxle controls.

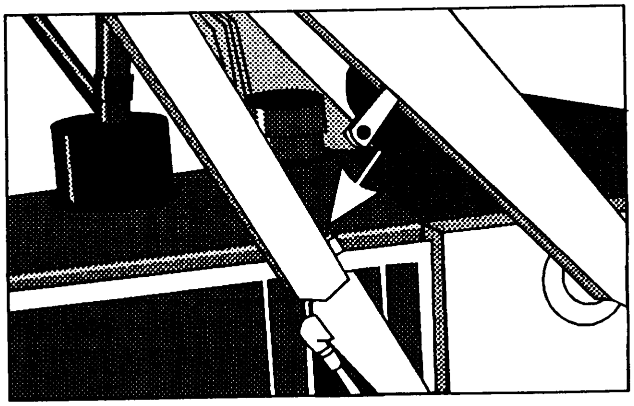


Figure 9-43.-Support strut.

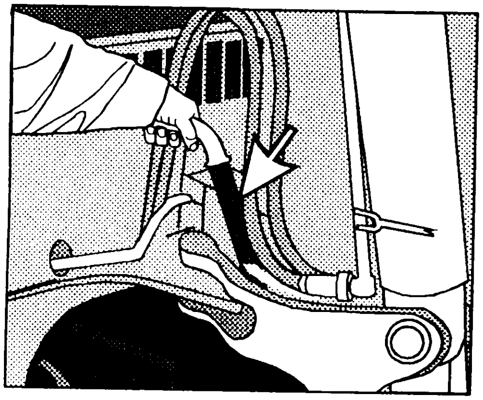


Figure 9-44.-Swing lockpin.

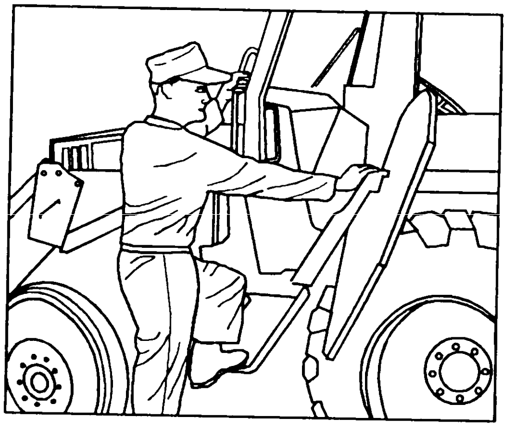


Figure 9-45.—Use handrails and steps to climb into the operator's seat.

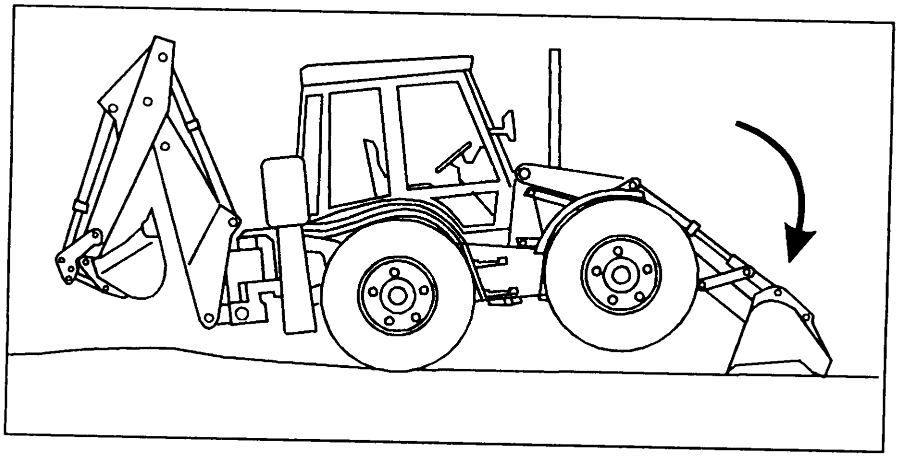


Figure 9-46.—Lower the bucket to raise the front wheels a few inches above the ground.

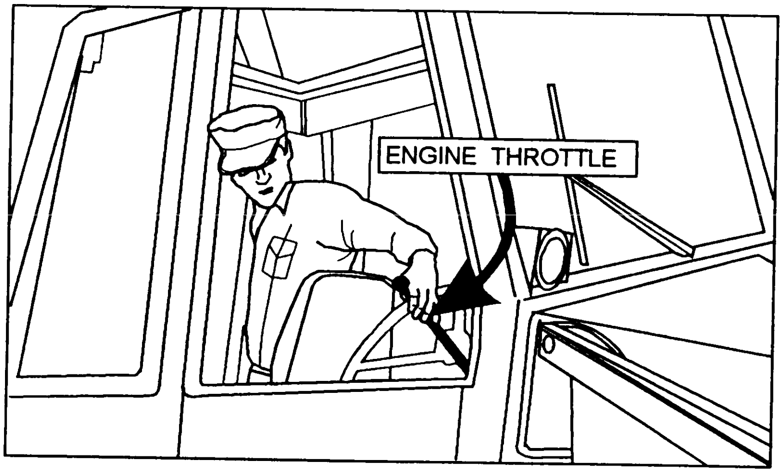


Figure 9-47.—Rotate the operator's seat and increase the engine throttle.

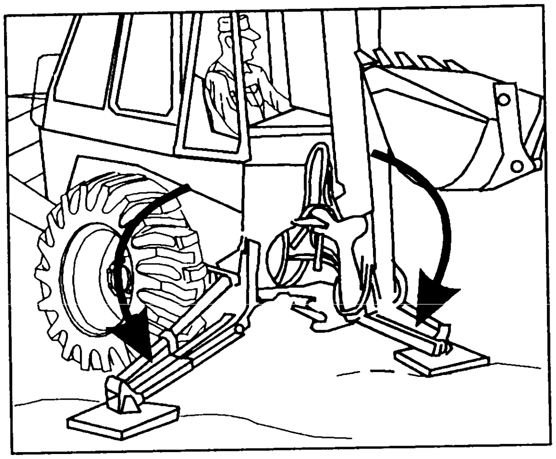


Figure 9-48.-Lower the stabilizers to raise and level the loader.

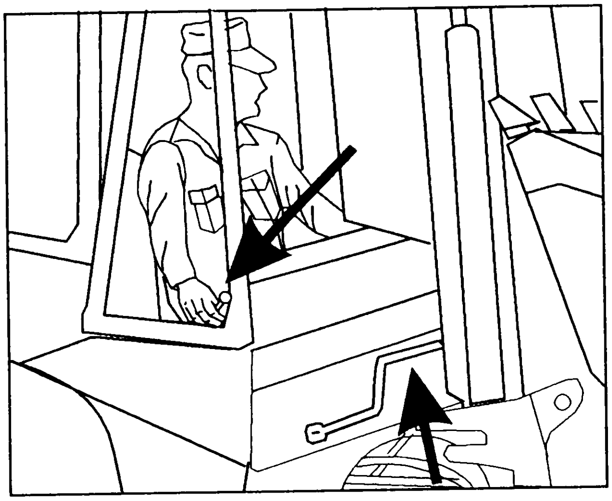


Figure 9-49.—Release the boom latch.

3. Install the rear pin in the support strut.
4. Slowly lower the lift arms onto the support strut.

WARNING

Failure to use the support strut when servicing the engine can result in **serious injury or death** if the loader arms are lowered by accident.

Backhoe operation is as follows:

1. Removed the swing lockpin (fig. 9-44).
2. Climb into the loader using handrails and steps (fig. 9-45).
3. Rotate the loader bucket into the dump position and lower it to the ground. Lower the bucket until the front wheels are a few inches above the ground (fig. 9-46).
4. Rotate the operator's seat to the rear of the loader for backhoe operation and increase the engine speed to full throttle (fig. 9-47).
5. Lower the stabilizers and raise and level the loader (fig. 9-48).
6. To release the boom latch, push the boom latch control lever to the left and hold it until the boom is released (fig. 9-49).
7. Extend the boom and bucket to start digging operations, as shown in figure 9-50.
8. To dig with the backhoe, move the dipper stick inward and fill the bucket (fig. 9-51, view A). Once the bucket is filled, curl the bucket inward (fig. 9-51, view B). Swing the boom and dump the material from the bucket (fig. 9-51, view C). Return to the trench and lower the bucket (fig. 9-51, view D).

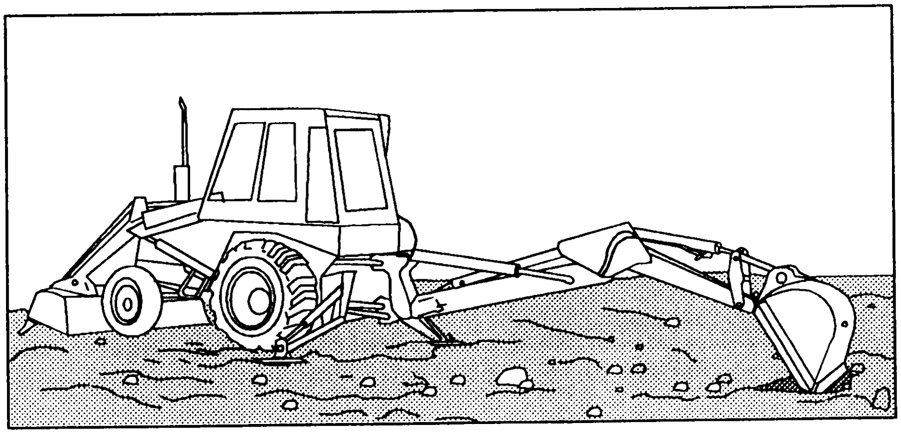
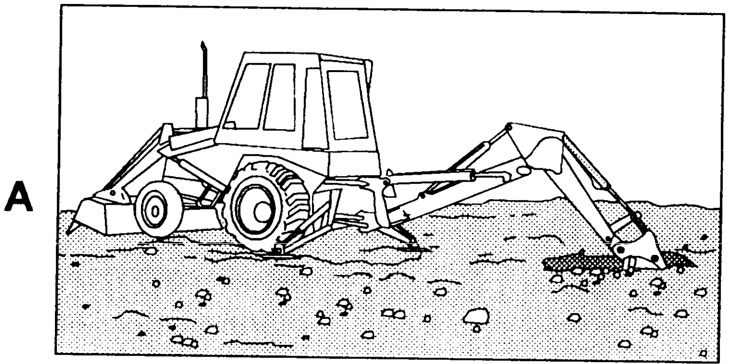
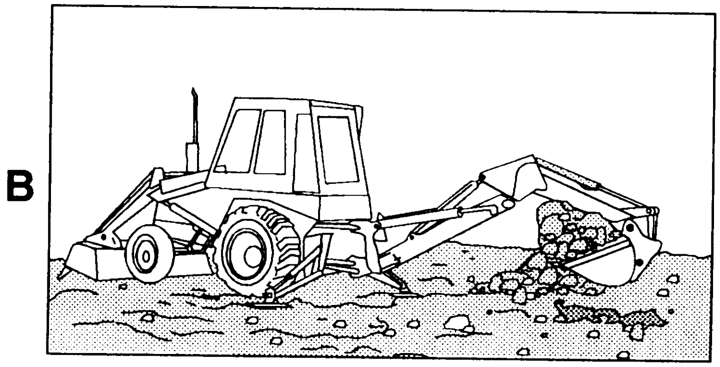


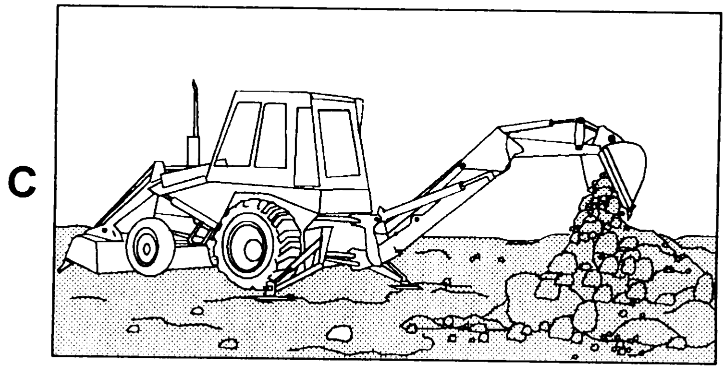
Figure 9-50.—Bucket and boom in position for digging operations.



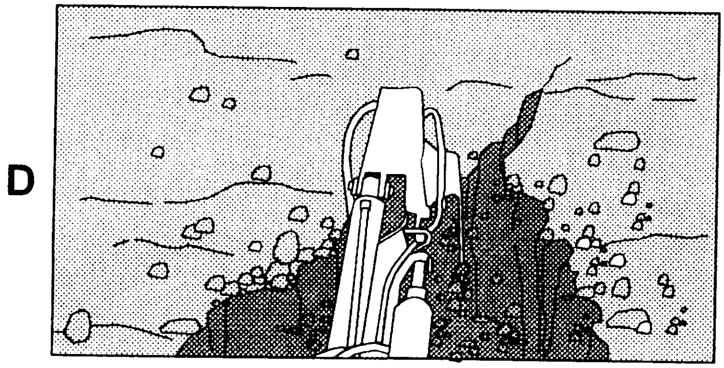
MOVE DIPPER IN AND FILL THE BUCKET



ROTATE BUCKET IN



DUMP THE BUCKET



RETURN TO THE TRENCH AND LOWER BUCKET

Figure 9-51.—Digging With the backhoe.

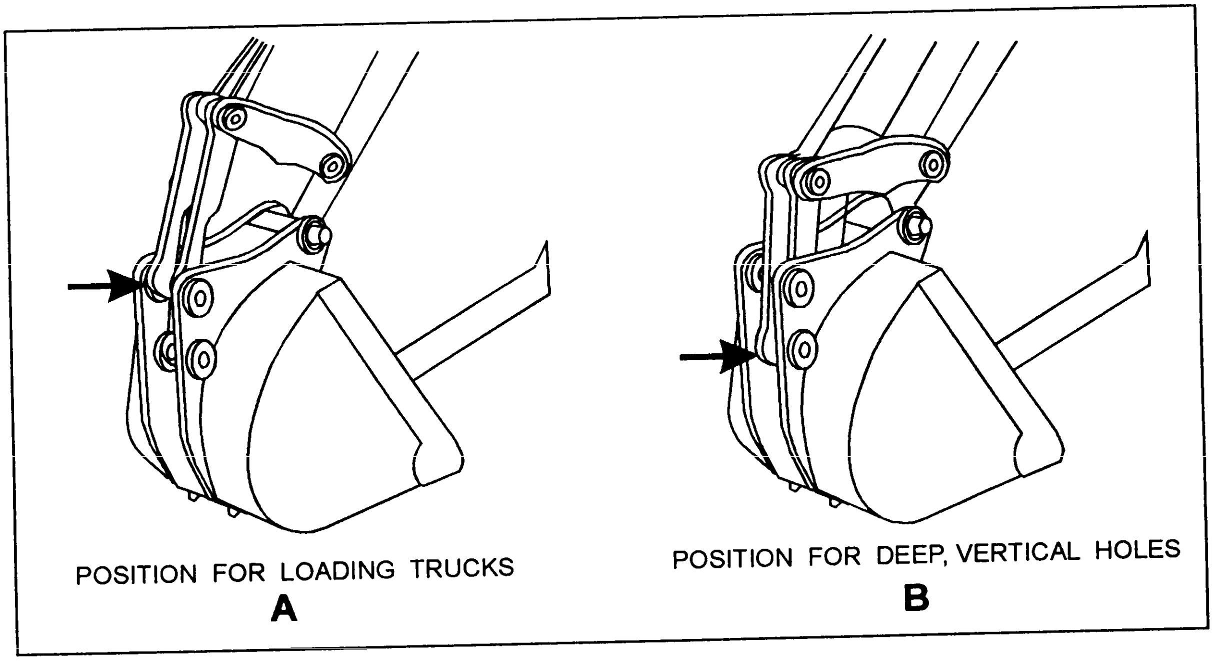

POSITION FOR LOADING TRUCKS
A
POSITION FOR DEEP, VERTICAL HOLES
B

Figure 9-52.—Backhoe bucket adjustment digging positions.

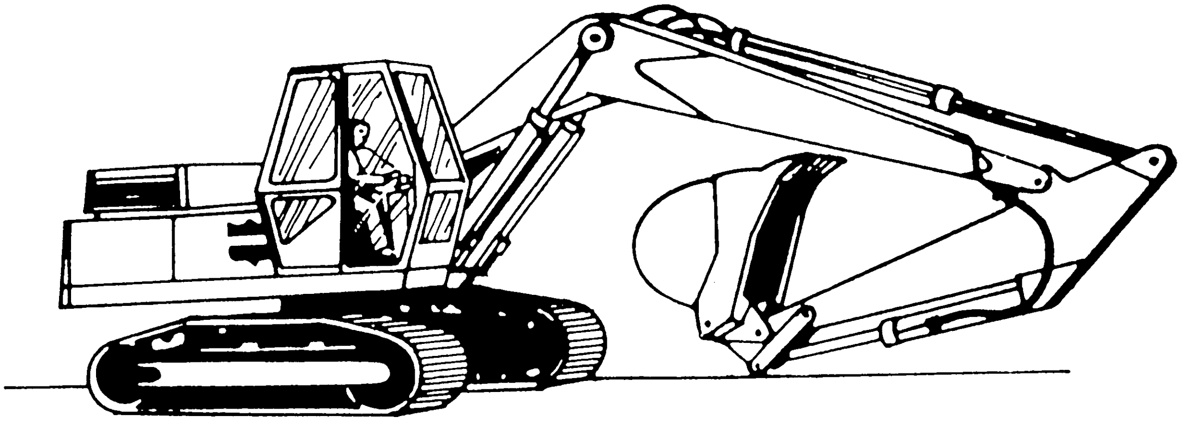


Figure 9-53.—Track-mounted excavator.

The backhoe bucket can be adjusted for two digging positions. The position for loading dump trucks is shown in figure 9-52, view A. The position for digging deep, vertical holes is shown in figure 9-52, view B.

The backhoe can dig more material in less time when a smooth, short dig cycle is used. When the bucket is forced to excavate a load that is too large (when the dipper stick control lever is pulled back and the bucket is not moving), a "hydraulic stall" results in the loader hydraulic system. When this occurs, the main relief valve of the hydraulic system makes a noise, alerting the operator to release the control lever.

NOTE: Hydraulic stalls cause the temperature of the hydraulic fluid to increase that can cause premature wear to the hydraulic system.

EXCAVATORS

Excavators are large backhoes used for heavier construction tasting. The types used in the NCF are either track mounted (fig. 9-53), truck carrier

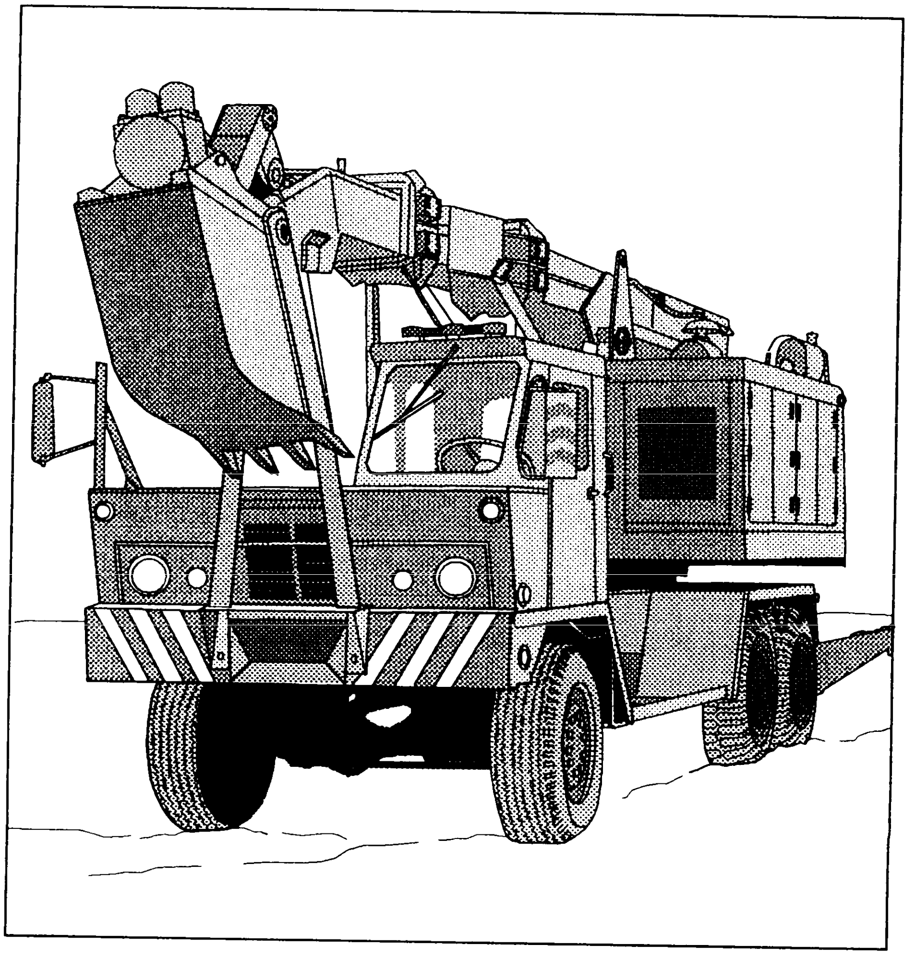


Figure 9-54.-Truck carrier-mounted multipurpose excavator.

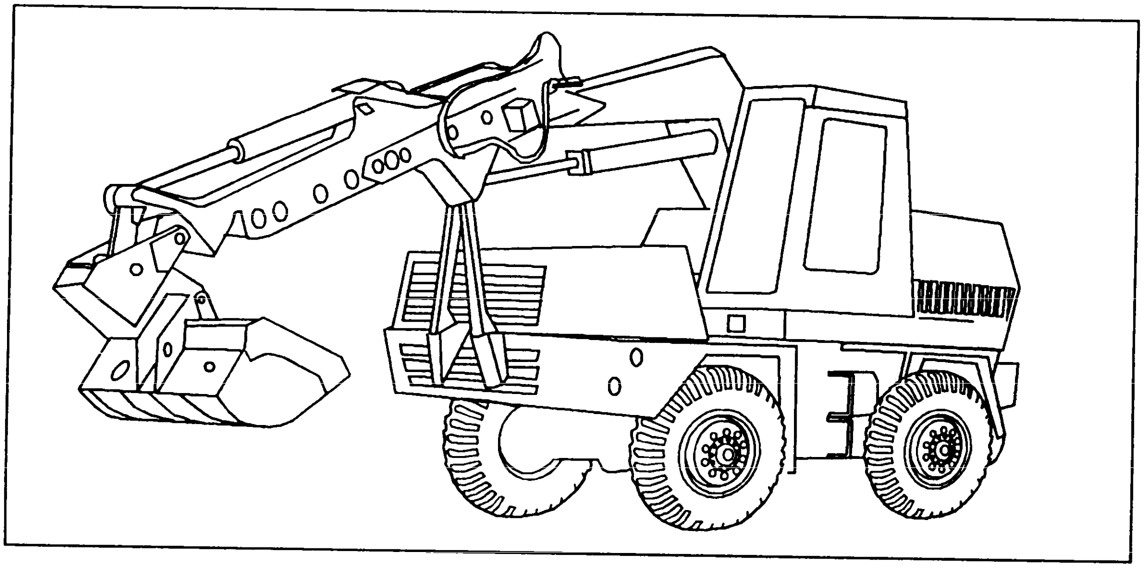


Figure 9-55.-Self-propelled wheel-mounted excavator.

mounted (fig. 9-54), or self-propelled wheel mounted fig. 9-55).

These excavators are hydraulic powered and consist of three structures: the revolving unit, the travel base, and the attachment.

REVOLVING UNIT

The revolving unit rests and revolves on a turntable and is normally a rectangular steel deck that carries the engine, the pumps, the attachments, the controls, and the operator's cab. The center of rotation is usually forward of the center of the revolving unit that places a major part of the revolving unit weight at the rear. This serves to counterbalance the weight and pull of the backhoe when performing excavation operations.

The swing axis is centered in the travel unit, so the rear edge of the revolving unit overhangs. This overhang must be accounted for when the revolving unit is rotated from side to side to avoid hitting personnel, equipment, and buildings.

The operator's cab is either mounted to the right or left of the boom and is the location of controls, gauges, and warning lights for all phases of operation. Some units may have fixed or removable front and side windows and a roof window that is helpful in watching out for and avoiding wires and tree branches. These windows should be cleaned during the prestart operation and anytime an amount of dust and dirt that has accumulated on the window obstructs your vision.

TRAVEL UNIT

The excavator travel unit may be track (crawler) mounted, truck mounted, or self-propelled wheel mounted. Of the three, the most common mounting is the track.

Rack Mounted

Track frames are single or double beams welded to the outer ends of the dead axles in the car body. The car body is a massive frame that includes the turntable and the dead axles or cross members that transmit its weight to the track flames. The track may be the link-shoe construction that is made up of a number of identical shoes cut and drilled at their ends, so they can be fastened together by pins (fig. 9-56). Wedge-shaped projections are cast into the upper surfaces of the shoes to provide a grip for the drive sprockets and to keep the tracks centered on the idler and rollers.

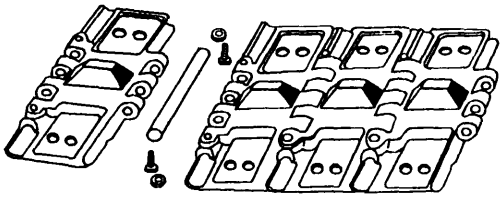


Figure 9-56.—Link-shoe construction.

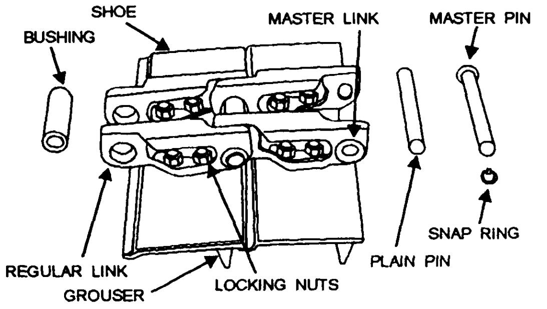


Figure 9-57.—Track links and bolt-on shoes.

The other type of track is the roller chain with bolt-on shoes. Each linked pair is fastened together with a bushing at one end. A pin goes through the bushing and holds the overlapping ends of the next pair of links (fig. 9-57). The track is assembled on a hydraulic press that is able to force the slightly oversized pins and bushings into the links that very seldom work apart in service. The pins turn easily in the bushing, providing the necessary hinge action.

The propel, traction, or travel drive may come from a pair of live axles set across the center of the car body or a pair of reversible hydraulic motors fastened to the track frame.

Truck Mounted

The revolving unit is carried on a turntable fastened to a truck chassis. Some units may have an engine mounted in the revolving unit to provide power for the upper unit controls and a engine mounted in the truck to be used for traveling. Some truck-mounted units may only have one engine used to power both the revolving unit and truck.

The truck-mounted excavator can ordinary swing in a full 360-degree rotation, but with most attachments, it can work through only 270 degrees because of interference presented by the cab and the truck front.

NOTE: A common rule of thumb is to never swing or perform work with a revolving unit over the cab or front of the truck.

Some truck-mounted units are equipped with outriggers mounted on the rear that increase the stability of the truck. These outriggers are normally hydraulically actuated and controlled from the cab of the truck and provide a much larger and more rigid base than tires.

The advantage of truck mounting over track mounting is its capacity for rapid movement from one job to another. The boom can be placed easily in the boom rest for traveling and then driven down the road at 25 to 35 miles per hour. This is better than the slow laborious job of trailer loading, securing, hauling, and unloading a track-mounted excavator.

The truck-mounted excavator suffers from a lack of maneuverability compared to the track mounting, because it requires a large area to turn around or to sidestep. Additionally, an important weakness is the ease with which it can get stuck. Constant care must be exercised to keep away from soft ground during or after it rains. Also, tire damage can occur when working in garbage dumps or a rock quarry.

Self-Propelled Wheel Mounted

The self-propelled single-engine unit has a two-range transmission, enabling it to travel between 3 and 28 miles per hour. Maneuverability on the job is subject to the same limitations as the truck mounted, except the short wheelbase, and in some models, four-wheel steering allows it in tighter places.

The self-propelled model has front axle oscillation lock levers. These levers are used to lock out the front axle from oscillating up or down, holding the axle rigid and level with the main chassis. The lock lever is used to help stabilize the excavator when working over the side.

NOTE: When reading, make sure the oscillation lock levers are up in the oscillate position, allowing the axle freedom to oscillate up or down.

The self-propelled model has a set of outriggers used to increase the stability of the unit. These outriggers are hydraulically actuated and are controlled from the cab and provide a much larger and more rigid base when the revolving unit is placed in the working position.

When traveling, always check the travel route for weight, height, and width limits, make sure the boom and steering selector are placed in the travel position, and the swing brake is engaged. Do not travel with the boom over the side of the excavator, and if traveling off of the road, do not travel faster than 5 miles per hour.

NOTE: After 2 hours of highway travel or every 50 miles, whichever occurs first, stop the machine to let the tires cool for 1/2 hour. Heat damages the tires and can cause tire failure.

ATTACHMENTS

All hydraulic excavator attachments are made of three strong structural members, such as the boom, the dipper stick, and the bucket (fig. 9-58). The structural members are hinged to each other, and the boom is hinged to the revolving unit. Movement at each hinge is controlled by two-way hydraulic cylinders.

Boom

The boom is normally concave towards the ground that allows space to pull the bucket closer to the excavator, permits deeper digging without interference from the travel unit, and enables the operator to see past it more easily when it is raised. There are two holes for connecting the boom cylinder rod eye to the boom (fig. 9-59). The top hole is for maximum digging depth, and the bottom hole is for maximum dump height. Be sure to read the operator's manual for instructions on the boom height-depth adjustment.

The outer end of the boom is usually prolonged into a two-piece bracket, in which the dipper stick is held by a heavy hinge pin or pins.

Dipper Stick

The dipper stick is usually one-piece, but some models may hydraulically extend and retract by a telescoping boom. The dipper stick hydraulic crowd cylinder is either connected on the top or on the bottom of the dipper, and the bucket and bucket dump arms are connected at the end.

If the dipper stick hydraulic crowd cylinder is mounted on the top, extending the cylinder forces the bucket in towards the machine, known as “crowding.” Retracting the cylinder forces the bucket outward, known as “extending.” When the cylinder is mounted underneath the boom, retracting the cylinder crowds the dipper stick, and extending the cylinder extends the dipper stick.

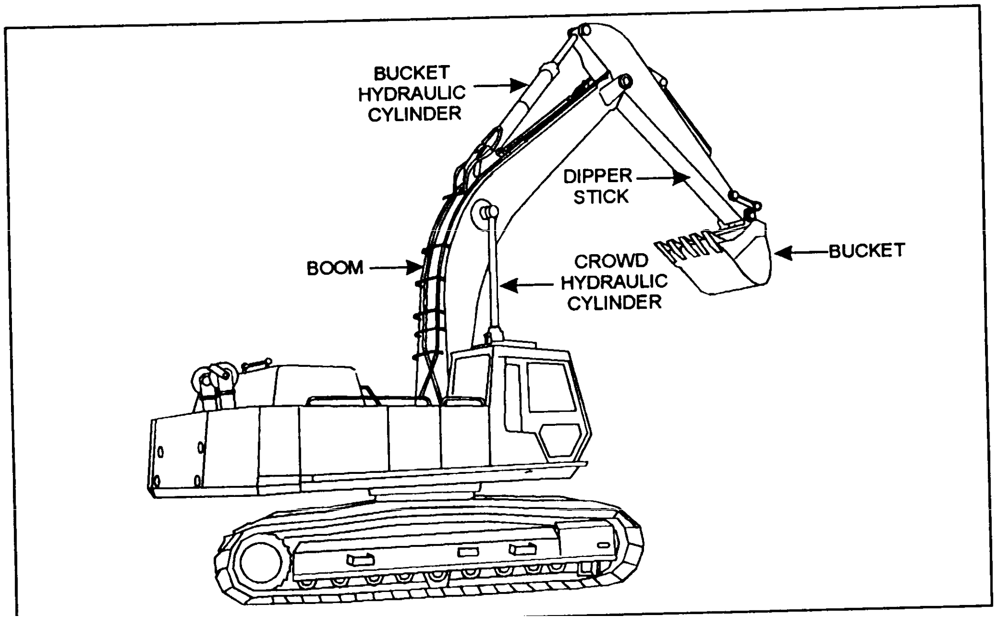
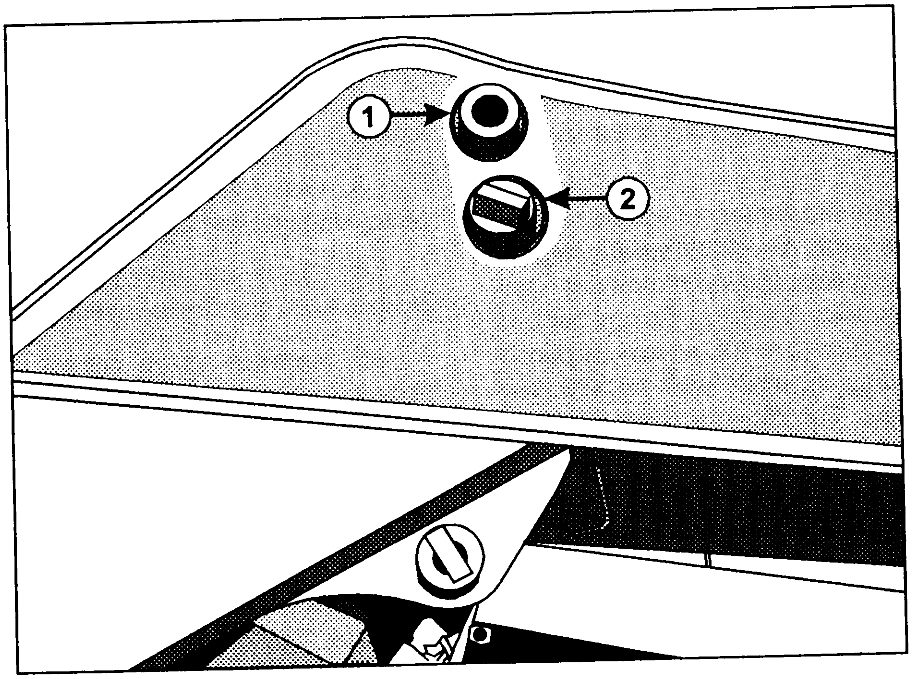

BUCKET HYDRAULIC CYLINDER
DIPPER STICK
BUCKET
BOOM
CROWD HYDRAULIC CYLINDER

Figure 9-58.—Hydraulic excavator structural members.



1. To increase the dig depth 2. To increase the dump height

Figure 9-59.—Boom depth-height adjustment.

WARNING

When working off the rear of an excavator that has the dipper stick hydraulic cylinder mounted on the bottom, in deep digging, caution must be taken to keep the dipper stick hydraulic cylinder far enough from the excavator to allow proper clearance when swinging.

The bucket cylinder is hinged to the top or front side of the dipper stick. The hydraulic cylinder rod is connected to the bucket dump arms that are hinged to the dipper stick.

Bucket Mounting

The bucket mounting is normally connected to the lower end of the dipper stick by a hinge pin and to a triangular set of paired dump arms. The other two angles of the arms are hinged to the bucket cylinder rod and to the dipper stick.

Dump arms supply the required around-a-curve reach and prevent the cylinder from being pulled in against the dipper stick when extending. The arm is necessary, because the bucket has such an extended arc of rotary movement around the dipper stick hinge that the piston arm could not follow it. When the hydraulic cylinder is extended, the bucket teeth move inward in a curling or digging motion. When the hydraulic cylinder is retracted, the bucket dumps, opens, or extends.

Bucket

The bucket can be attached to the bucket mounting in a variety of ways. One way is the slow process of removing cotter pins and manually driving out hinge pins to change the attachment. Another way is a "quick-latch" mounting where the pins are retained in the attachment and the quick-latch mounting latches on the pins and is secured to the attachment by a large bolt. A third way is a quick disconnect that uses hydraulic controlled locking pins that the operator controls from the cab.

Buckets are supplied in a number of widths, ranging from 24 to 59 inches or more. A bucket is usually slightly wider at the opening to reduce friction at the sides when digging and to allow easier dumping. Narrow buckets tend to be deep in proportion to width and may fill poorly in chunky or rocky digging, while wide buckets may have poor penetration. The digging edge is almost always equipped with teeth that are removable for reversing, sharping, or replacement (fig. 9-60).

In the NCF, there are other attachments that are used in excavator operations. These attachments range from a grader blade, hydraulic power compactor, perforated dredge bucket, bull prick (jackhammer), ripper, and so forth. These attachments are maintained by the attachment custodian in the transportation yard.

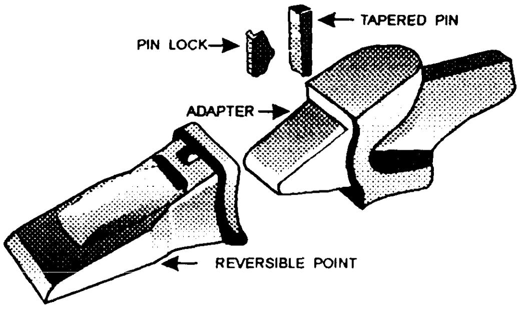


Figure 9-60.-Detachable tooth.

When you are using attachments, remember these rules: (1) always maintain clearance between the attachment and the cab to prevent equipment damage and possible injury; (2) when not in use, store attachments on a hardstand or wood to keep the items out of sand, mud, and water; and (3) seal hydraulic lines and fittings for protection from dirt and moisture.

DIGGING PROCEDURES

If you are unfamiliar with the control or basically have not operated a backhoe in a while, use a slow engine speed while you familiarize yourself with each control. At first, operate the controls separately, then operate two or more controls at the same time. Basic digging procedures are as follows:

1. Wear the proper personal protective equipment for the job, including steel toe safety shoes, a hard hat, and gloves.

2. Check the ground conditions before you start to dig.

3. Obtain a digging permit and know the location of any underground cables and pipelines.

4. Check for overhead obstructions, such as electric lines, tree limbs, and awnings.

5. Remove large rocks, stumps, or other obstructions before you begin to dig.

6. When you are digging, use a digging stroke that will fill the bucket. Full buckets are more efficient and faster than half-full buckets.

7. Try different digging angles with the bucket to find the best cutting effort for the material you are removing. The best digging angle cuts the material as you fill the bucket.

8. When filling the bucket, keep the bottom of the bucket parallel with the cut, as shown in figure 9-61, view A.

9. Let the bucket teeth and the cutting edge cut through the ground like a knife blade, as shown in figure 9-61, view B.

10. Curl the bucket to retain the cut material, as shown in figure 9-61, view C.

11. The type of material excavated will determine how much material can be excavated with each cycle.

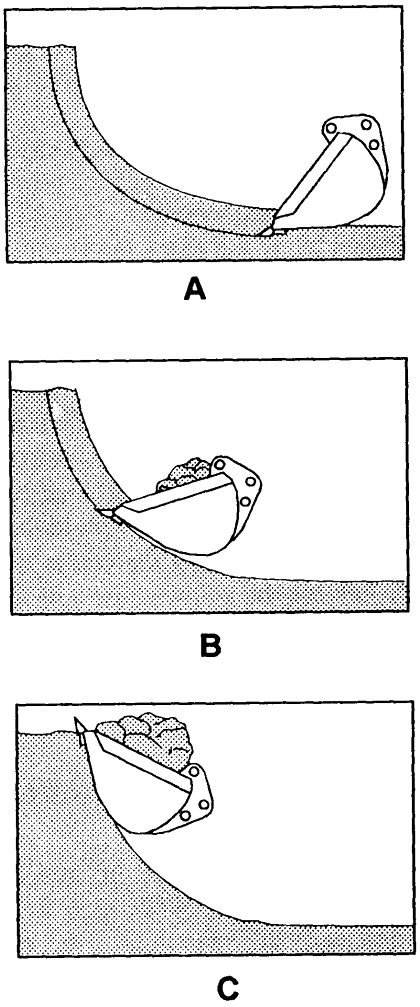


Figure 9-61.—Filling the bucket.

JOB LAYOUT

Many excavation jobs are small and routine. Other jobs may be quite extensive. On small jobs, you will normally be shown where to dig and to what depth you must dig. On larger jobs, you maybe shown the plan of the proposed ditches. Grade stakes on the projects are marked to indicate to what depth the ditches must be excavated. (Chapter 15 covers grade stakes in detail.)

NOTE: Before starting any excavation, you must ensure a valid digging permit is present that covers the area you are tasked to excavate.

When arriving at the project site, you may notice two rows of grade stakes: one row on the center line of the proposed ditch and the other row offset a given distance from the center line. Do not disturb the offset stakes. They are the stakes you will follow while excavating the ditch that have information relative to the depth of the excavation written on the side.

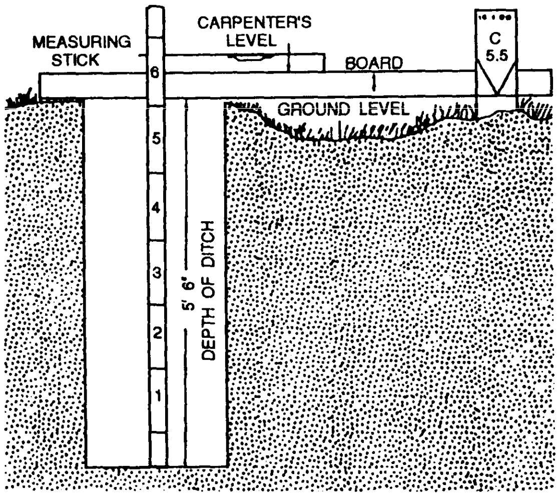


Figure 9-62.—Measuring the depth of a ditch.

As a guideline, you can use a string drawn taut from the first centerline stake to the following centerline stakes for a distance of several hundred feet ahead of the machine. Then spray paint over the string with a bright-colored paint that will mark the ground to be excavated. With the bucket centered over the first centerline stake, you will be able to excavate the painted line. If you get off center, you can bring the backhoe back into alignment gradually by steering the machine in the desired direction.

Check your grade (ditch depth) frequently. You can do this by using a straight board, a carpenter's level, and a measuring stick or tape measure. Align the corner bottom of the horizontal board on the crowfoot cut, marking of the offset stake. Place the level on the horizontal board and adjust the board opposite the stake until the level indicates the board is level. Measure from the bottom edge of the board to the bottom of the ditch, as shown in figure 9-62. This measurement should correspond to the amount of cut indicated on the stake. All of the stakes will be cut stakes. You should always try to excavate to the depth specified on the stakes.

NOTE: It is better to excavate an inch or two below grade than not excavate deep enough.

FOUNDATION EXCAVATION

The backhoe is used to make excavations for basements or any other square- or rectangular-shaped job. It is also used extensively for digging wide trenches for laying water and sewer pipe. When the backhoe is used for the digging of square- or rectangular-shaped jobs, the procedures may vary with the shape of the job, restrictions caused by surrounding buildings, or special requirements for disposal of the spoil. In all cases, the starting point and digging sequence must be planned, so the backhoe conveniently works itself out into the clear. Improper procedures will not only trap the machine, but can lead to situations where the machine cannot be positioned to complete the job. In this situation, hand digging may be required to complete the excavation.

An accepted starting and digging sequence that can be followed for excavating a small foundation is shown in figure 9-63. Remember that digging time is lost each time the machine must be moved. The digging sequence is planned, so a maximum amount of spoil can be excavated before the machine is moved to the next position.

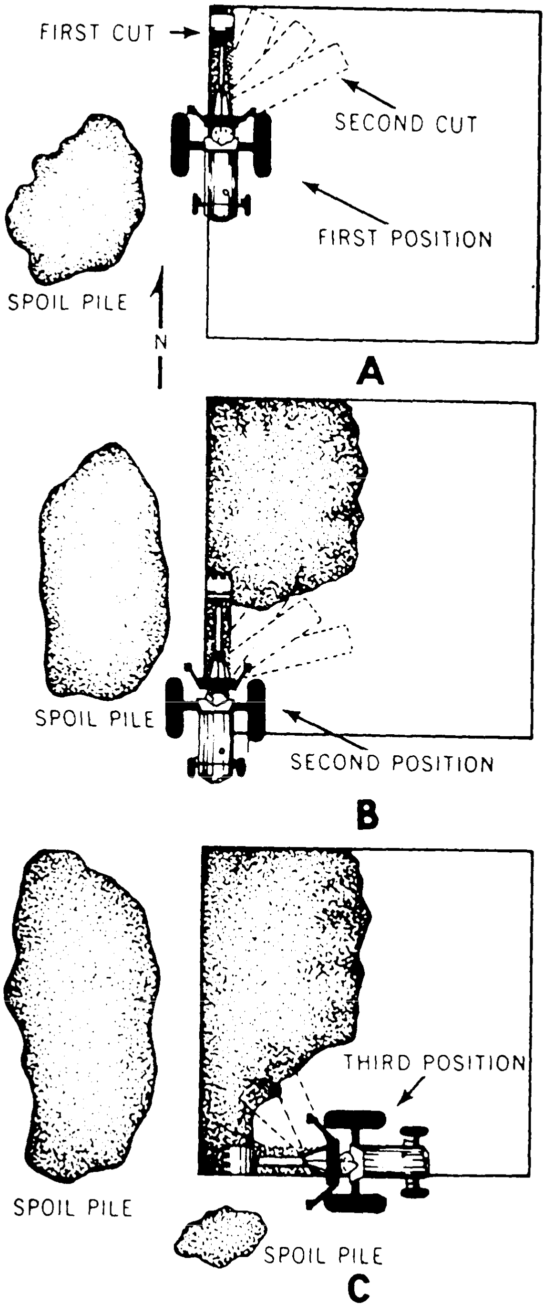


Figure 9-63.—Foundation excavation.

For example, the first cut is to be made on the west line (fig. 9-63, view A). The starting position of the machine would be on the west line at a point where the boom and dipper stick will reach the northwest corner. The machine and boom are lined up parallel with the west cutting line, so the outer edge of the bucket is exactly in line with the cutting line.

The first cut is made by digging a ditch along the west cutting line. The ditch should be dug to its full depth and grade. This depth and grade serves as a depth guide for the other cuts. When the west wall has been dug as close as possible to the machine position, you then swing the boom to reach near the center of the north cutting line. The second cut, as shown in figure 9-63, view A, is made by digging a trench back from the north wall. The material cut in the angle formed between these two trenches is removed in layers until the bottom grade is reached.

NOTE: Ensure that the desired grade is reached before moving the backhoe.

The backhoe is then backed up into the second position, as shown in figure 9-63, view B. Digging is continued in steps, as shown in figure 9-63, view A. The ditch is dug first along the west line. The boom is then swung around to cut the angle trench and the material is removed to grade. Digging is continued in this manner until the south line is reached.

The backhoe is then moved to the unexcavated portion of the south line. This position is shown in figure 9-63, view C. Here, the backhoe is positioned with the bucket in the excavation at the southwest corner to begin the ditch along the south cutting line. Again, after the ditch is dug along the cutting line, you should swing the boom toward the center to remove as much spoil as possible from this machine position.

You should continue to move the backhoe around the excavation, repeating the digging steps until all four cutting lines are cut and the spoil removed. To make the final cut to remove the material, you may have to position the machine at the edge so the bucket can dig straight up. This cannot be done unless the soil type is known to have good-bearing qualities. Cave-ins will result if the soil will not support the weight of the machine.

NOTE: Before excavating at a jobsite, always consult with the project supervisor or crew leader about your excavation plans. Keep in mind that the area you might be placing the spoil material might be an area for other construction tasking. Excavating at a jobsite must be a well-thought-out plan.

SAFETY

Safety precautions that apply when you operate front-end loaders, backhoes, and excavators are as follows:

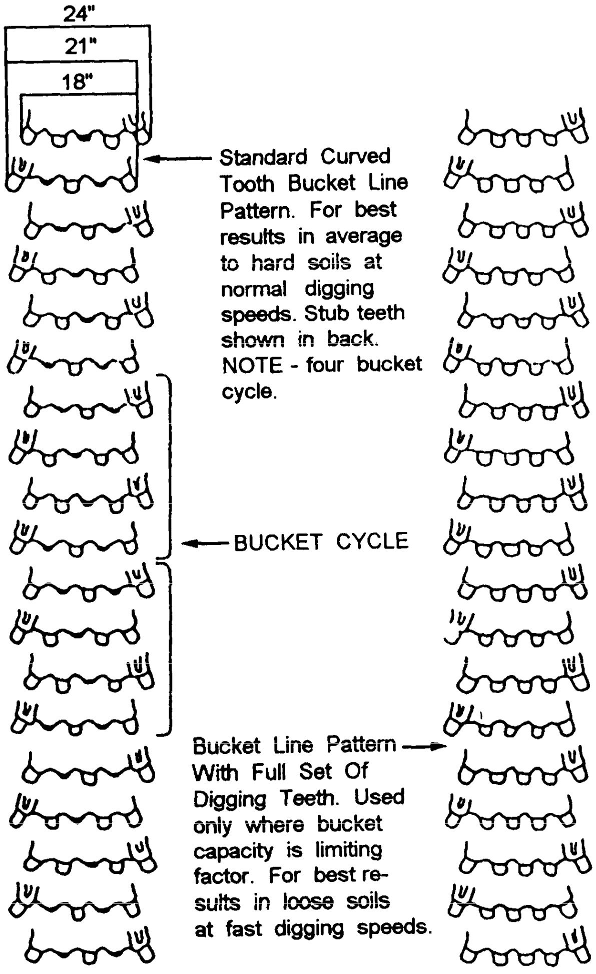
- Clear the immediate area of personnel or obstructions before starting the engine.
- Keep the bucket as close to ground level as possible when transporting loads on grades or slopes.
- Never operate any control from any position except in the operator's seat.
- Be extra careful when working on banks or hillsides.
- Always keep the machine in gear when going down steep grades. Never coast or freewheel.
- Drive at speeds slow enough to ensure safety and complete control especially over rough terrain.
- Reduce speed when making turns or applying brakes.
- Always lower the lift arms or boom to the ground or block them securely before performing any service or when leaving the machine unattended.
- Never dismount the loader, backhoe, or excavator when it is in motion.
- Never permit anyone to ride on the equipment.
- Do not oil, lubricate, or make adjustments when the engine is running or the bucket is raised and unblocked.
- Never refuel when the engine is running.
- Do NOT smoke when refueling.
- Never operate in a closed area; provide proper ventilation.
- Do not wear loose fitting clothing which may catch in moving parts.
- Always wear seat belts, steel toe safety shoes, hard hats, gloves, and other required personal protective equipment.

DITCHERS

A ditcher, despite its name, is seldom used for digging a ditch, which is a slot cut in the earth's surface and left open. The ditcher is a mechanical excavator used to dig trenches, which is a temporary cut in the earth for underground utilities, such as pipelines and conduit to handle water, fuel, electric cable, and sewage. Once these materials are placed, the trench is covered. Additionally, the ditcher may also be used to dig footers for building foundations.

All ditchers have bucket teeth (fig. 9-64). The ditcher teeth cut the earth and play a major role in how

NOTE - When the cutting width is increased it will be necessary to increase the width of the follow-up crumber. This is done by adding one of the scraper extension plates to the side of the crumber corresponding to the side of the bucket line on which the side cutters have been added.



Standard Curved Tooth Bucket Line Pattern. For best results in average to hard soils at normal digging speeds. Stub teeth shown in back. NOTE - four bucket cycle.

Bucket Line Pattern With Full Set Of Digging Teeth. Used only where bucket capacity is limiting factor. For best results in loose soils at fast digging speeds.

Figure 9-64.-Two basic bucket teeth designs.

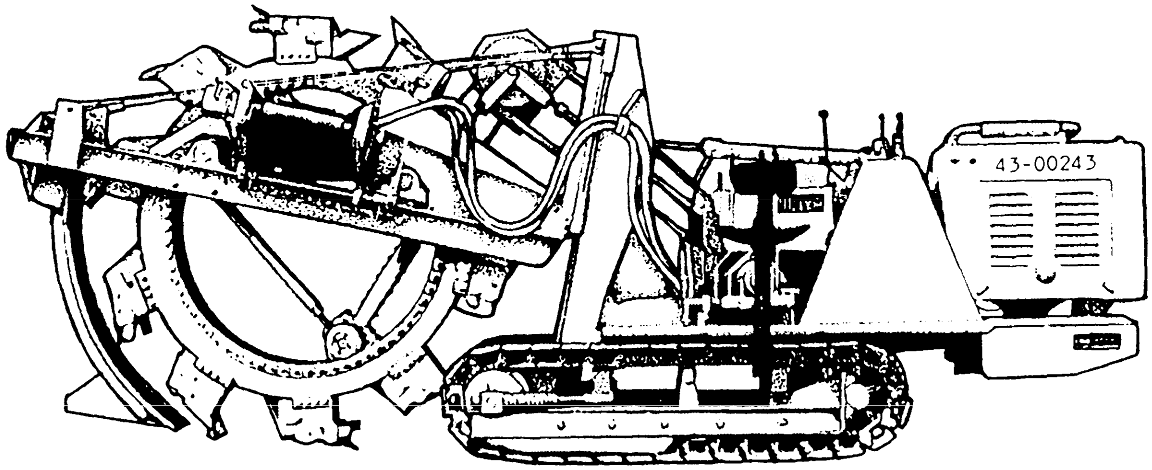


Figure 9-65.—Wheel ditcher.

your machine performs. Figure 9-64 shows two examples of teeth patterns normally used. When the teeth wear down about one-half inch and before the face of the bucket shows wear, ensure the teeth are reversed or replaced.

NOTE: Always install a complete set of teeth on a bucket when reversing or replacing teeth.

If only a few new teeth are installed here and there along the bucket line, the new teeth will cut the most and wear down much faster than would a whole new set. However, if only one or two teeth show too much wear or are broken or chipped, they may be reversed or new ones installed in their place if the rest of them are in good shape.

Three types of ditchers used in the NCF are the wheel ditcher, the ladder ditcher, and the chain ditcher. The most common ditcher is the ladder ditcher. Read the operator's manual to obtain detailed information on the care, maintenance, and operation of a given ditcher.

WHEEL DITCHER

On the wheel ditcher (fig. 9-65), the digging buckets are mounted on a large wheel. The wheel is attached to a frame type of horizontal boom that can be raised and lowered, and the ditcher has a spoil conveyor for carrying the excavated material out to either side of the machine.

To start a cut, lower the turning wheel into the ground, and then watch the bucket teeth start to dig. As the ditcher itself is stationary, apply enough pressure to the buckets so they fill "heaping" without gouging deep enough to slow the wheel.

The ditch will have a rounded beginning, as shown in figure 9-66, views A and B. Be sure the position of the center of the wheel is over the starting point for the full depth of the ditch, so the ditcher has enough room to dig down to the desired depth at the beginning of the cut (fig. 9-66, view B).

NOTE: Before starting any excavation, you must ensure a valid digging permit is attained that covers the area you are tasked to ditch.

Digging

When the wheel is at the correct depth, you should move the machine forward just fast enough to keep the buckets reasonably full. Crowding too hard overworks the engine and strains the digging parts without adding to the output.

Soft rock usually responds best to a high-wheel speed with very slow walking speed. If dirt is soft, you may crowd it so the dirt in excess of the bucket capacity piles on each side of the ditch without damage.

Experience will help when selecting the right combination of digging and travel speeds for various types of soil; however, consult the operator's manual for

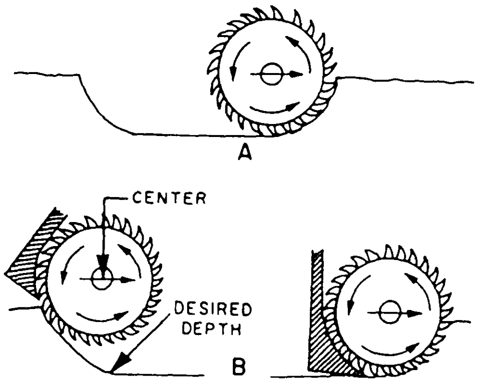


Figure 9-66.-Starting a cut with a wheel ditcher.

guidance on digging and travel speeds for the type of ditcher used.

Obstructions

Where boulders, heavy roots, or pipelines could be met, you should adhere to the following guidelines:

- Both walking and wheel speeds should be slow.
- Soft boulders are cut through by the teeth. Depending on how buried a hard boulder is, it may be pulled to the surface or forced forward. This is because the deeper boulder not only is held down by a greater weight of dirt but also the direction of the tooth contact tends to force it forward, rather than up.
- The wheel will usually ride over embedded boulders that cannot be removed by the ditcher. If a large boulder is near the surface of the cut, it may stop the forward motion of the machine; in which case, power should be cut off promptly.
- If a boulder is pulled to the surface, it may land in an inconvenient spot, forward of the wheel and between the tracks. You may have to lift the wheel into transporting position, work forward until clear of the rock, push it out of the way, and backup until the wheel can be lowered to the ditch bottom. If the boulder is too large for the wheel to clear, release the wheel drive clutch so the wheel can turn as it is pulled over it.
- When the wheel is lifted above grade to clear any obstruction, it maybe worked back to grade at the other side in the same way the cut is started.
- Turn with caution while digging. Slight turns cause the wheel to move sideways in the trench. If the buckets have long side teeth or side-cutting bars and the earth is soft, you can make a gradual turn without damaging the wheel assembly. Sharp turns may cause severe damage, such as bending the wheel frame, bending the wheel itself, or pulling the wheel frame off the vertical track.

LADDER DITCHER

The boom on the ladder ditcher (fig. 9-67) cannot be brought closer than about 35 degrees to the vertical.

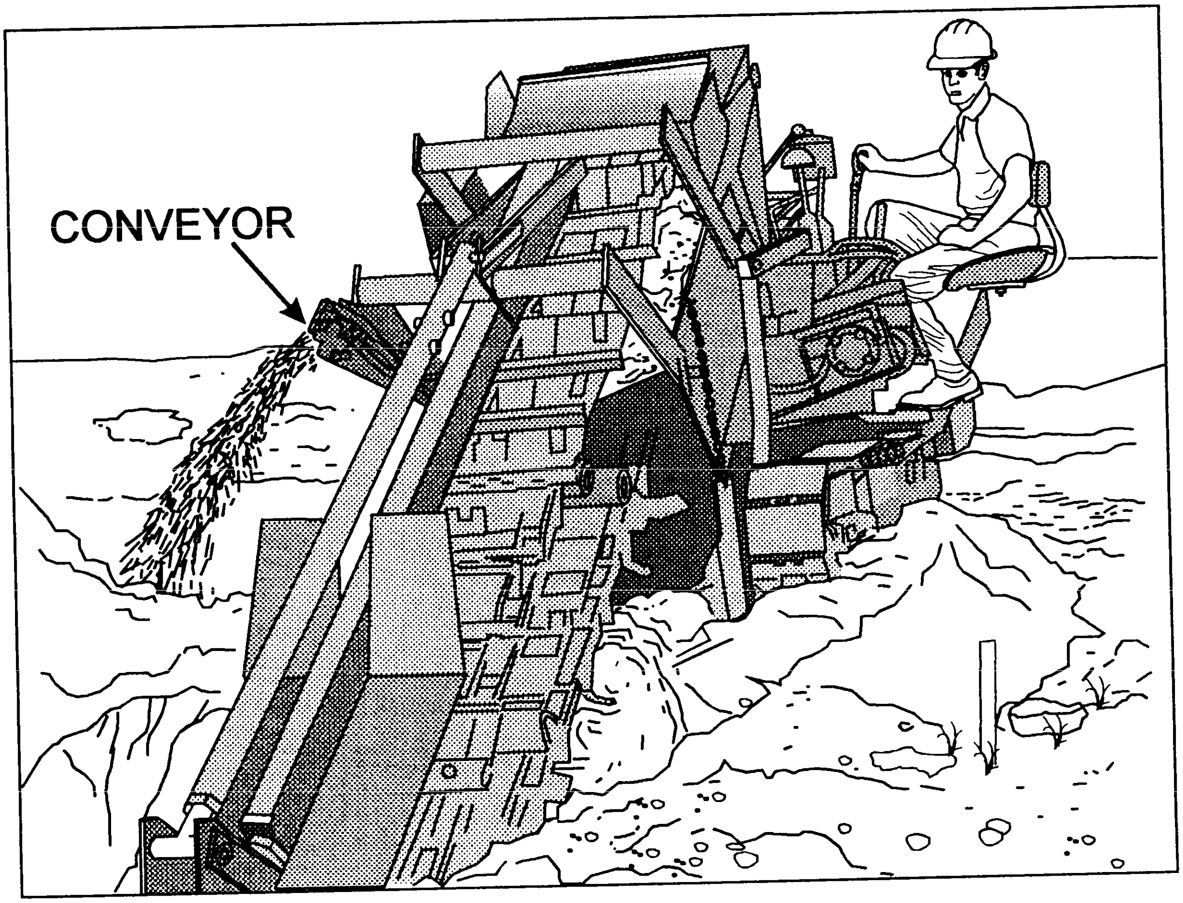


Figure 9-67.—Ladder ditcher.

With the ladder ditcher, excavating is done by buckets attached to the bucket line chain; the chain travels on the drive sprockets on the boom assembly. Like the wheel ditcher, the ladder ditcher has a spoil conveyor to carry the excavated material out to one side or the other. The radius of a curve depends mainly on the density of the soil to be excavated. Turns should be made cautiously at a slow-digging speed and only to where the boom starts binding between the trench walls.

The crumber shown in figure 9-68 has a major job to clean out and smooth the ditch after the teeth have cut the material. The crumber is adjustable and should be adjusted so it will clean the ditch of loose materials behind the teeth.

CHAIN DITCHER

The chain ditcher, as shown in figure 9-69, has teeth attached to a chain similar to a chain saw. The chain teeth pull or drag the cuttings to the surface, rather than lifting them in a bucket. The cuttings are usually moved back from the edge of the ditch by rotating augers.

Chain ditchers are ideal for lightweight work, such as sprinkler systems, gas lines, and small waterlines. Some of these machines can dig up to 10 inches wide and 4 feet deep.

CAPABILITIES AND LIMITATIONS OF DITCHERS

A ditcher can dig earth material ranging in texture from soft to hard; however, as the material being excavated increases in hardness, the production rate decreases. Table 9-1 gives maximum trenching rates for classes of soils in feet per minute.

A limitation of a wheel, ladder, or chain ditcher is that ramps are left at the bottom of the trench ends and around buried objects. To obtain a flat-bottom trench, you must remove these ramps by hand. The wheel ditcher digs faster in dense material and is preferred for cross-country digging where speed is needed.

OPERATING TECHNIQUES

In most ditching work, keep the machine in line and working at the proper depth. Unable to see the ditch bottom, you (the operator) must use surface controls.

First, the ditch is surveyed and the depth of cut is determined by the EAs from the blueprints. You, the EO, establish a guideline at a fixed and constant distance above the bottom grade of the trench and offset from the center line of the trench beyond the track line of the ditcher.

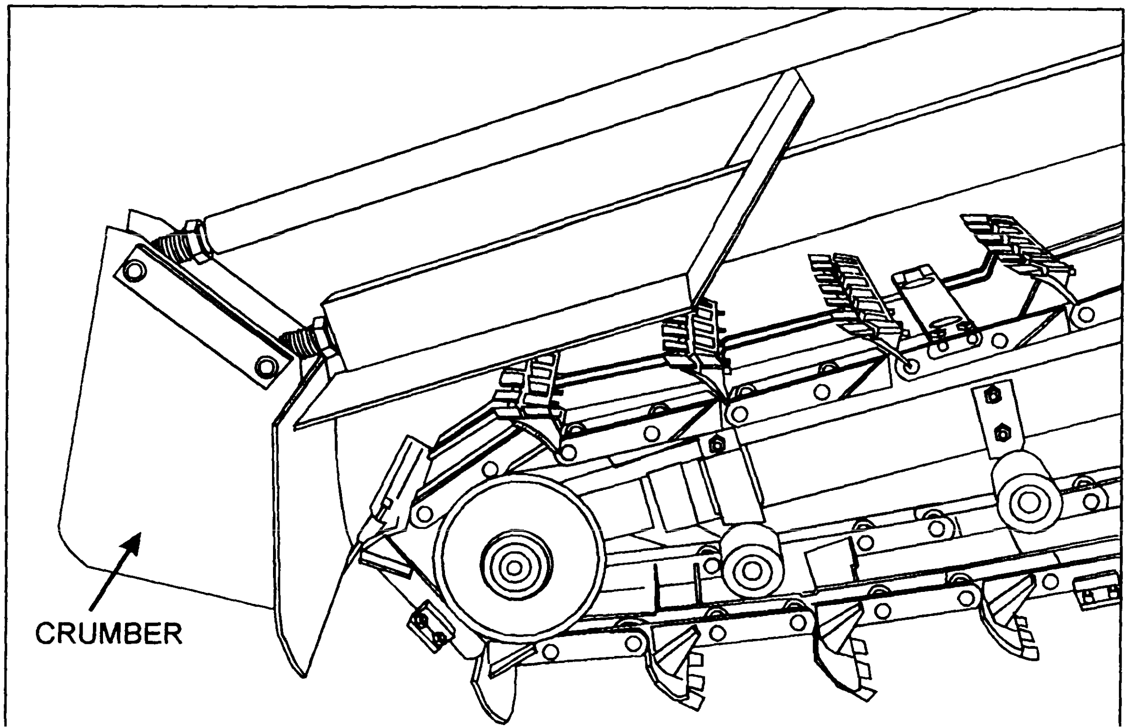


Figure 9-68.-Crumber.

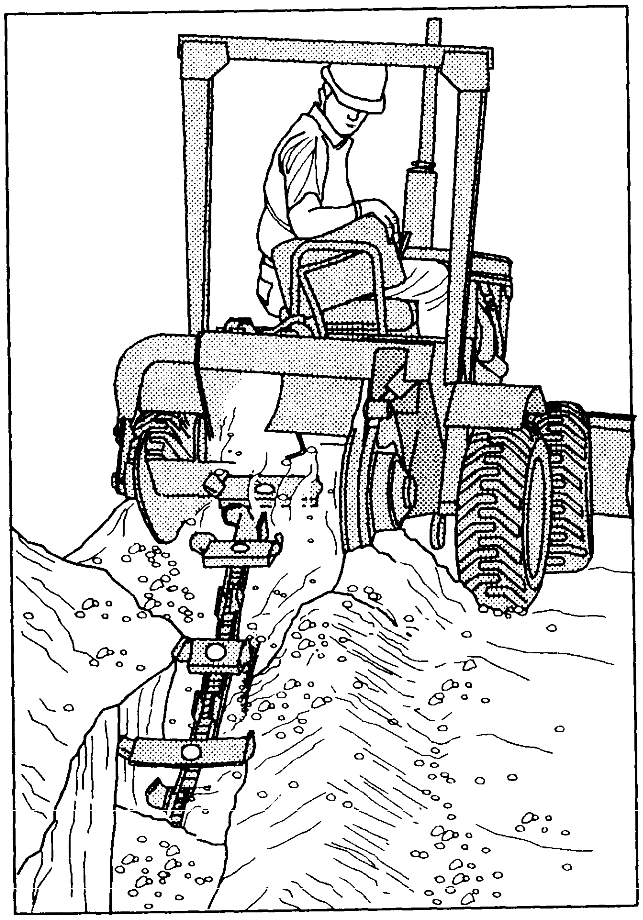


Figure 9-69.—Chain ditcher.

The guideline should be established at a height that will put it at least a few inches above the ground at all points, stakes driven along it, and the exact height or depth of the cut marked. Then a string line is stretched along the stakes on these markings.

A rigid bar is fastened to the front of the power unit of the ditcher with one end over the string when the ditcher is centered on the ditch line. A plumb bob or other weight is fastened to the bar, so it hangs directly over the string. The operator can then keep the machine on center of the trench, cut by keeping the plumb bob just over the string. If the ground is irregular and causes the ditcher to go up and down, the cord holding the plumb bob can be run through eyes or pulleys, so the operator can reach an end of the cord to raise and lower it.

The same device (plumb bob or other weight) can be fastened on the side beam of the boom or wheel with a fixed length of string to control the depth of cut and center line travel of the ditcher.

Table 9-1.—Crawler Ditcher Maximum Trenching Rates

PRODUCTION IN FEET PER MINUTE					
DEPTH OF TRENCH	DRY TO MOIST SAND	SOFT DRY CLAY	MOIST CLAY	HARD CLAY & GRAVEL	STICKY CLAY
1 ft. 6 in.	32	28	26	22	16
2 ft.	25	22	20	17	12
2 ft. 6 in.	20	18	16	14	10
3 ft.	16	15	13	11	8
3 ft. 6 in.	14	13	11	10	7
4 ft.	12	11	10	8	6
4 ft. 6 in.	11	10	9	7	5
5 ft.	10	9	8	6	4

Cutting Curves

The radius of a curve cut while excavating a trench with the ditcher depends mainly on the density of the soil excavated. In sandy or loose soil, the radius can be much less than in hard, compacted, and rocky soil. The turn for the ditcher should be made cautiously at a slow digging speed and only to where the boom starts binding between the trench walls.

Muddy Trenching

The two major problems when trenching in muddy materials are loss of traction and a buildup of material in the buckets. The traction can be increased by putting planking under the tracks or by adding wider crawler pads. To cope with material sticking to the teeth and buckets, you can run the digging chain faster, so the material will not be forced into the cut. In this way, you do not force and pack wet, sticky material into the bucket and between the teeth; otherwise, the material in the bucket gets stuck and cannot empty completely.

Transporting

A ditcher is slow and must be hauled between jobsites. It must be loaded and unloaded safely and properly. The design of the ditcher requires that it be used on a smooth, gradual incline. When loading on a tilt-bed trailer, you must be careful; the sharp incline of the trailer could make the ditcher hang up. Additionally, the smooth tracks of the ditcher tend to slip.

NOTE: Do not load a ditcher on a tilt-bed trailer in damp, wet weather.

The combination of the ditcher design, brakes, and smooth tracks makes it almost impossible to stop on an incline while loading or unloading; therefore, it is important to use a proper ramp or loading platform to load the ditcher. For safety, load and unload the ditcher in low gear, and if you do not have a proper ramp, see that a crane is used to load and unload the ditcher.

SAFETY

The following are standard safety precautions for ditchers:

- Do not leave the operator's seat unless you have stopped the ditcher and disconnected all power from the engine to the ditcher.
- Do not engage the engine clutch too fast. Let it engage gradually to prevent damage to the gear cases and other moving parts.
- Do not fill the fuel tank with the engine running.
- Do not let bolts and keys come loose. Be alert for unusual sounds or odors. These are danger signs and should be investigated to prevent downtime.
- When the ditcher is secured, the bucket line must always be raised clear of the trench.
- Ditches left open must be flagged by day and properly lighted at night.
- Do not let anyone work or stand close to the digging boom. In a cave-in, the person might be pulled into the boom or other moving parts. Also, if an electrical line is hit, people standing nearby could be hurt.
- Before digging, be sure you have a digging permit. You should know and have marked all underground obstructions.

CAUTION

Never try to remove an object from the conveyor belt while the conveyor is running.

- Never raise the boom of the ditcher more than you have to while on an incline, because the ditcher is easily upset.
- Wear the required personal protective equipment, such as steel toe shoes, hard hat, and gloves.

CHAPTER 10

GRADERS AND SCRAPERS

In the Naval Construction Force (NCF), graders and scrapers are essential tools used in the construction of airfields, ammo supply points (ASPs), roads, and site work. The primary purpose of the grader is to cut and move material with the blade for final shaping and finishing. The scraper is a large earthmover with the capability of digging, loading, hauling, dumping, and spreading material. This chapter covers the characteristics and basic principles of graders and scrapers operations.

GRADERS

Graders are multipurpose machines used primarily for general construction and maintenance of roads and runways, moving large amounts of materials laterally by side casting. Additionally, the grader can be used for crowning and leveling roads, mixing and spreading materials, ditching and bank sloping, blade mixing asphalt materials, snow removal, and scarifying.

The grader is a rubber-tired hydraulically operated, single-engine unit. The single engine provides power for all grader functions. The steering system, moldboard, and scarifier are hydraulically controlled.

Although the grader, at times, must be hauled to and from jobsites, the grader has an advantage over other heavy equipment because of its capability to travel over the road under its own power.

NOTE: When hauling a grader with a tractor-trailer, ensure the height of the grader cab clears all overhead obstacles.

A variety of makes and models of graders are used in the NCF. Each operator is responsible for reading the operator's manual to obtain detailed information about each make and model.

GRADER COMPONENTS

The basic grader consists of a prime mover and a grader mechanism. The principal parts of a grader are shown in figure 10-1.

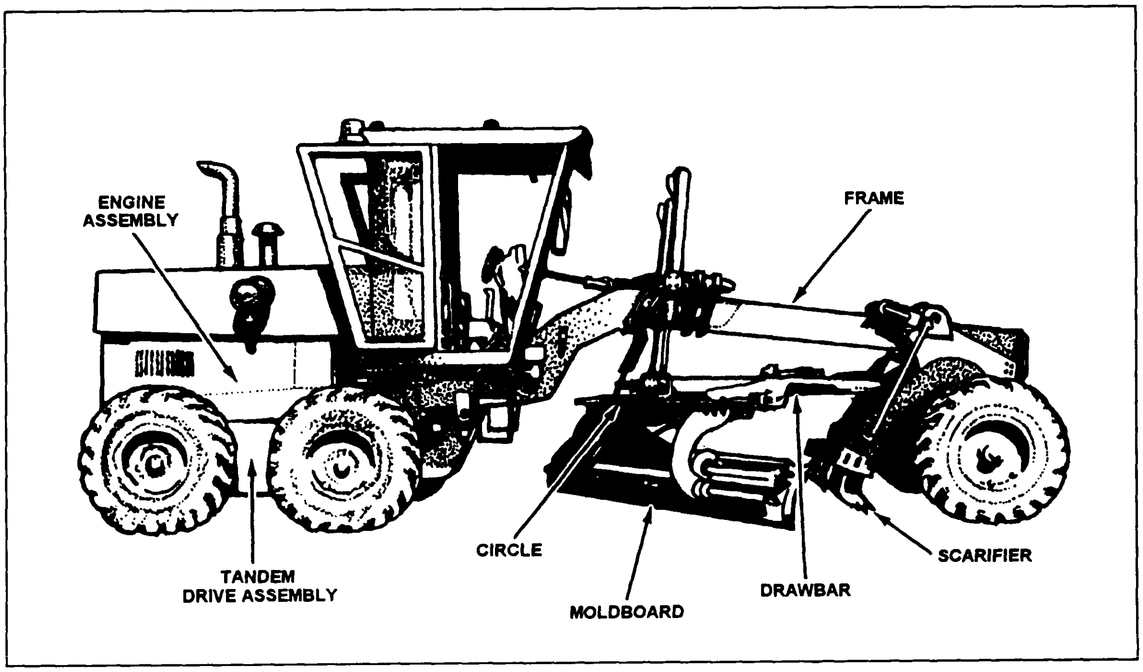


Figure 10-1.—Principal parts of a motor grader.

Prime Mover

The prime mover is a rubber-tired tractor, power-driven by a four- or six-cylinder diesel engine mounted at the rear. The prime mover has four-rear mounted single tires driven in tandem drive through gears and chains and a single-steering axle.

TANDEM DRIVE.— The tandem drive of the grader allows climbing over rocks, logs, or humps, and permits passing through depressions or ditches one wheel at a time. Having the capability to operate in this manner, one rear wheel can raise or lower, while the other remains on the same level with the front wheels thereby holding the grader on a level terrain (fig. 10-2). This is a very important feature. If the rest of the grader does not rise and fall when working uneven terrain, the grader blade does not vary its elevation, as the grader passes over its work.

ARTICULATED FRAME STEERING.— Some graders have frames that are hinged just forward of the

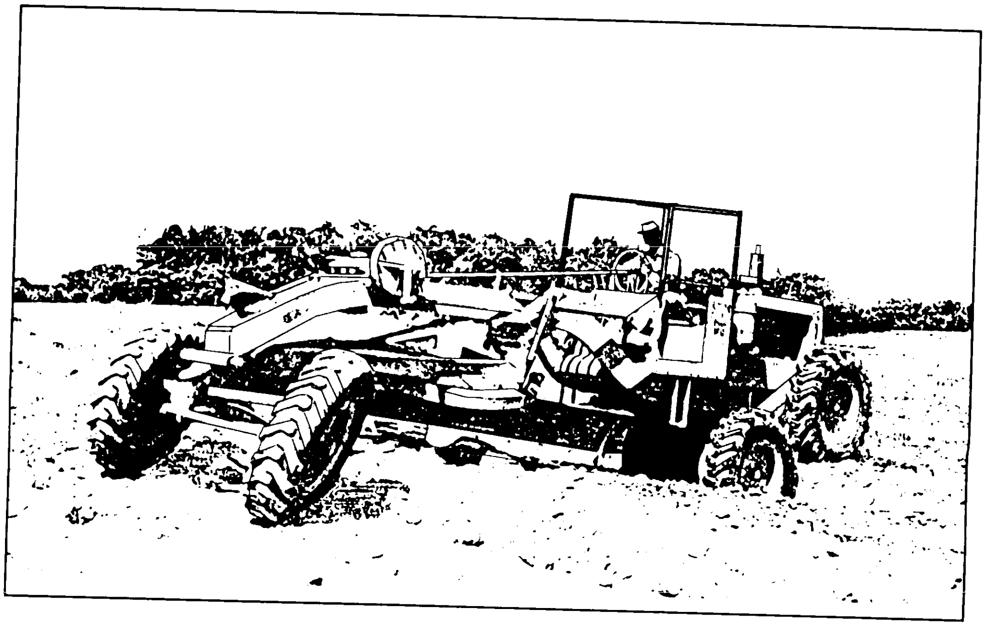


Figure 10-2.—Tandem drive.

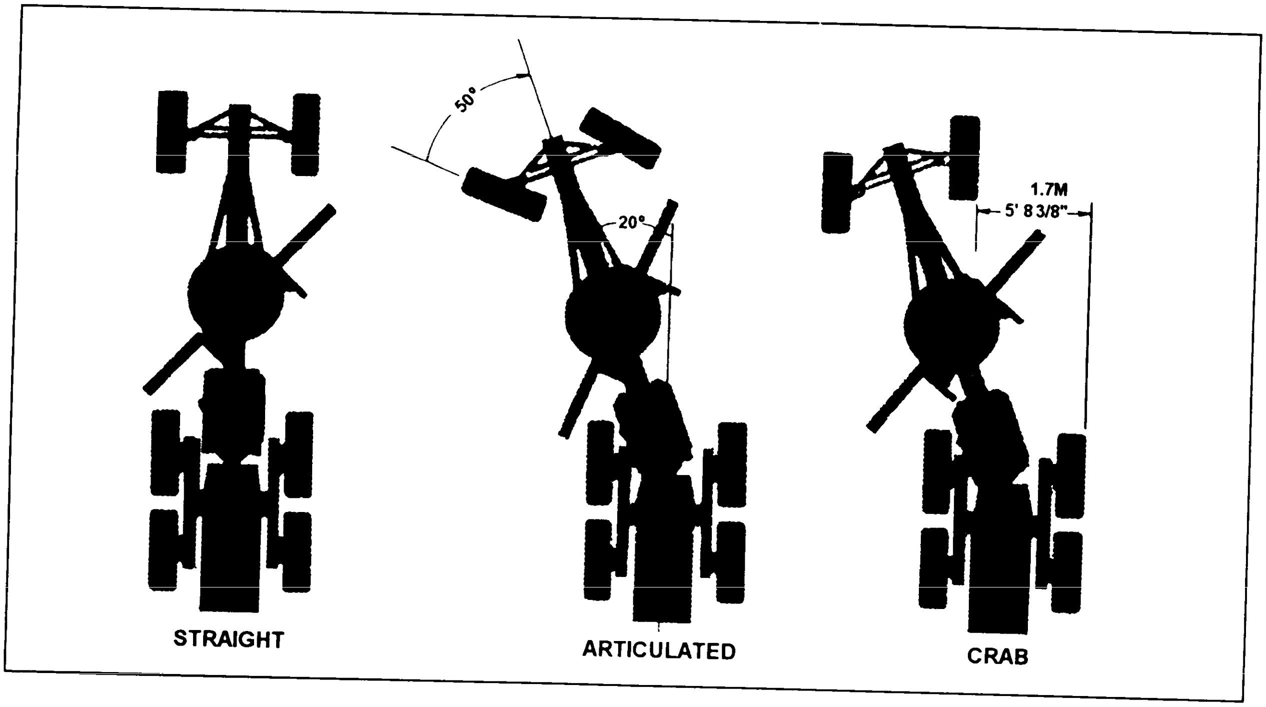


Figure 10-3.—Articulated grader.

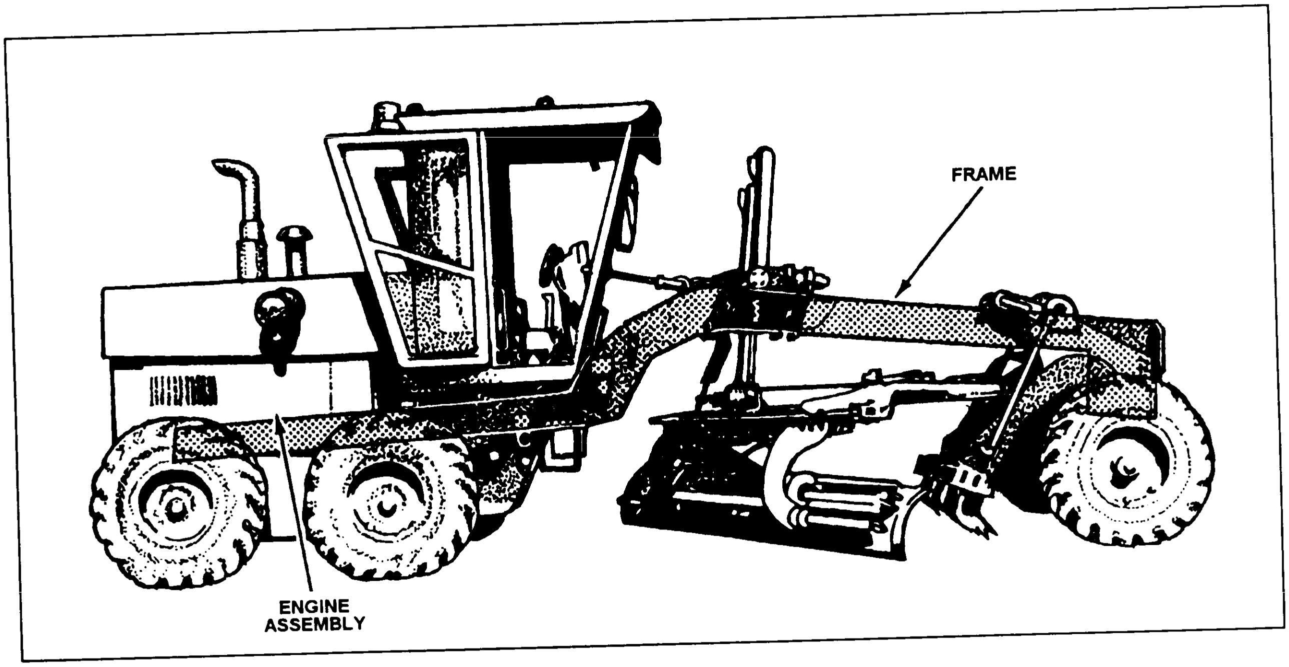


Figure 10-4.-Grader frame.

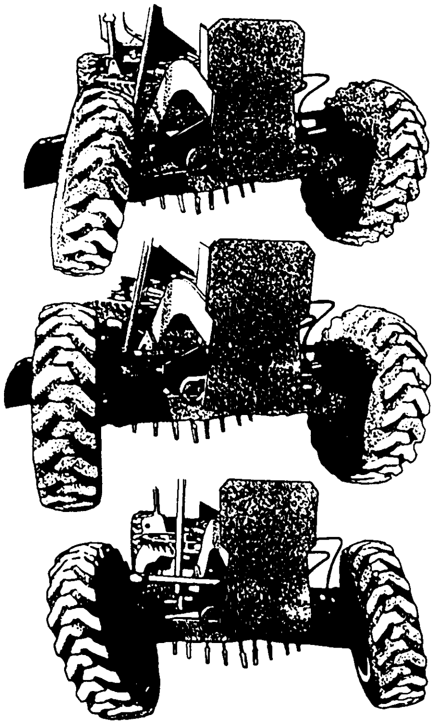


Figure 10-5.—Front axle.

engine with articulating controlled by a pair of hydraulic cylinders. The articulated frame steering allows for an increase in productivity and stability. The articulated frame has a shorter turning radius than the conventional grader (fig. 10-3). This allows for easier maneuvering in close quarters and quick turnaround at the end of a pass and enables the grader to carry a full blade of material around a curve. Crab steering helps compensate for side drift when turning a windrow, keeps tandems on a firm footing when clearing ditches, and increases stability on side slope work.

NOTE: Before articulating the grader, be aware of the position of the grader blade. With the blade angled in an acute position, articulating the grader sharply can position the rear tires to run into the blade.

Frame

The frame connected to the front axle extends the full length of the grader (fig. 10-4) and is high enough to allow space for carrying and manipulating the grading mechanism.

The front axle is compound. The lower section carries the weight of the grader, oscillates on a center pin, and is hinged to the bottom of the wheel spindle. The upper section of the axle is hinged to the top of the spindle, allowing the front wheels to lean as well as turn (fig. 10-5).

Moldboard

The moldboard with the cutting edge and end bits attached is called the **blade.** The blade is the working

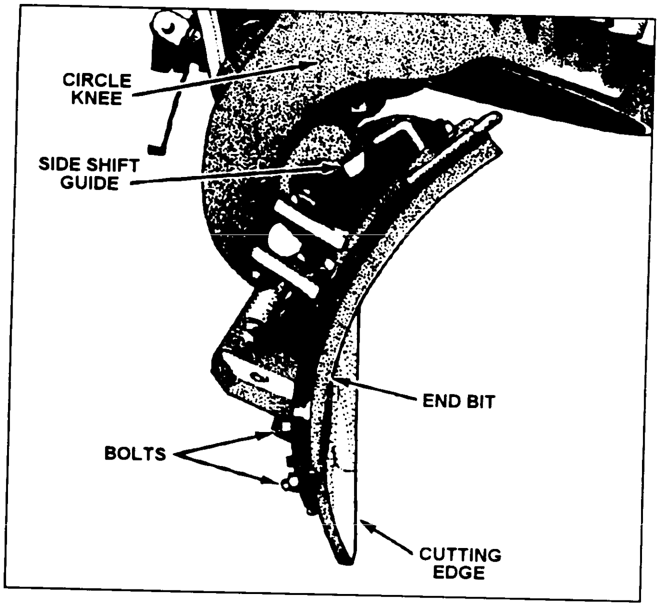


Figure 10-6.-Moldboard.

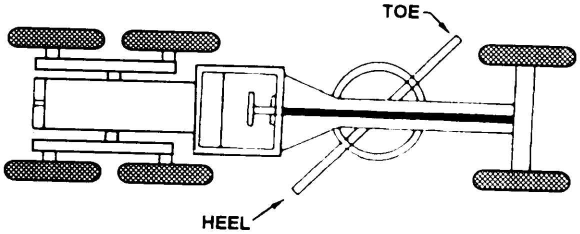


Figure 10-7.-Blade heel and toe.

tool of the grader that can be lifted, lowered. rotated. tilted forward and backward, shifted to one side or the other, and angled horizontal (fig. 10-6).

The cutting edge and end bits are bolted to the moldboard. They act as wear plates and must be replaced or reversed when worn or broken. In most cases, the bolts will have to be replaced too.

NOTE: Always keep enough cutting edges and end bits on hand to protect the moldboard from wear or damage.

The length of the blade is normally 12 or 14 feet. The curve shape of the blade causes dirt to roll and mix, as it is cut and moved. The rotary movement of the dirt combined with the angle of the blade causes a side-cast drift of the material.

When the blade is angled to position one end ahead of the other, two terms are used to designate the blade ends. They are the *heel* and the *toe* of the blade. Figure 10-7 shows that the toe is the leading edge of the blade; the heel is the trailing edge. When the blade is turned so the toe is to your left, as you sit in the operator's seat, the material will side cast to your right and spill

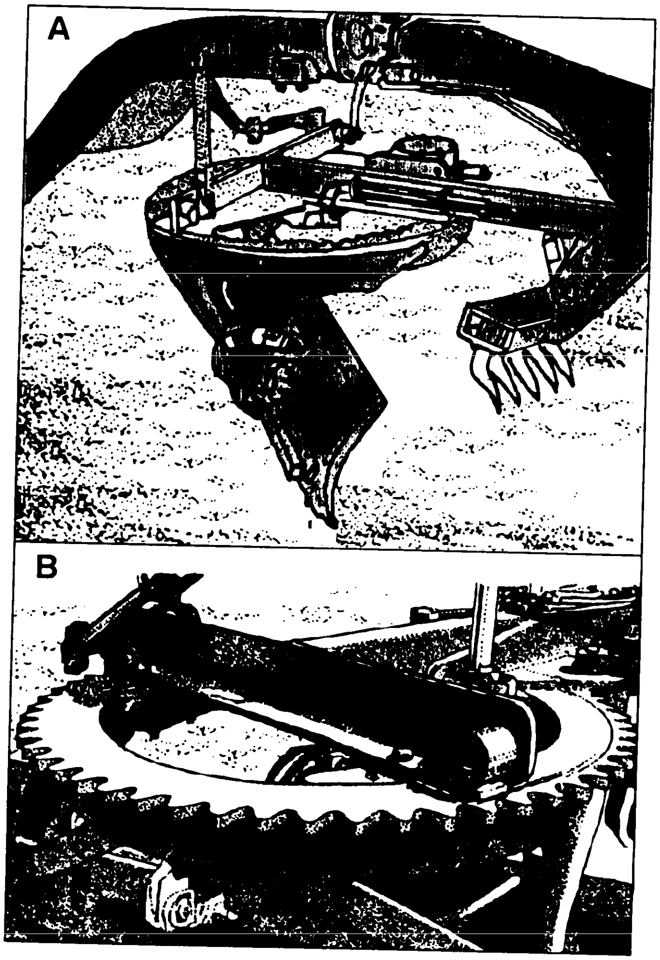


Figure 10-8.—Circle.

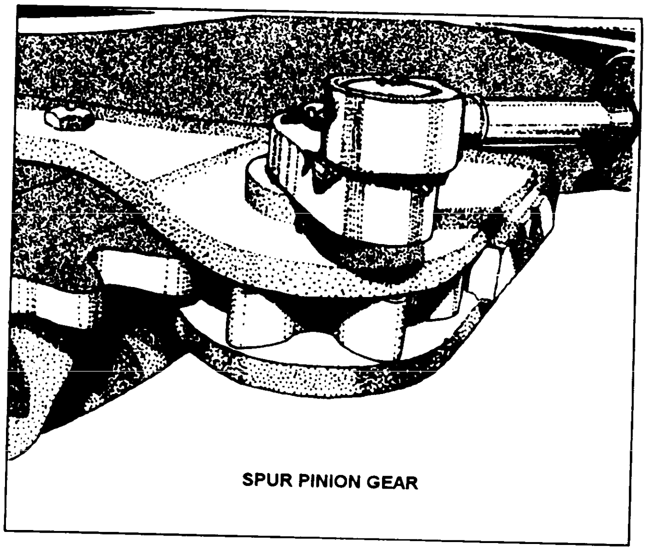


Figure 10-9.-Spur-pinion gear.

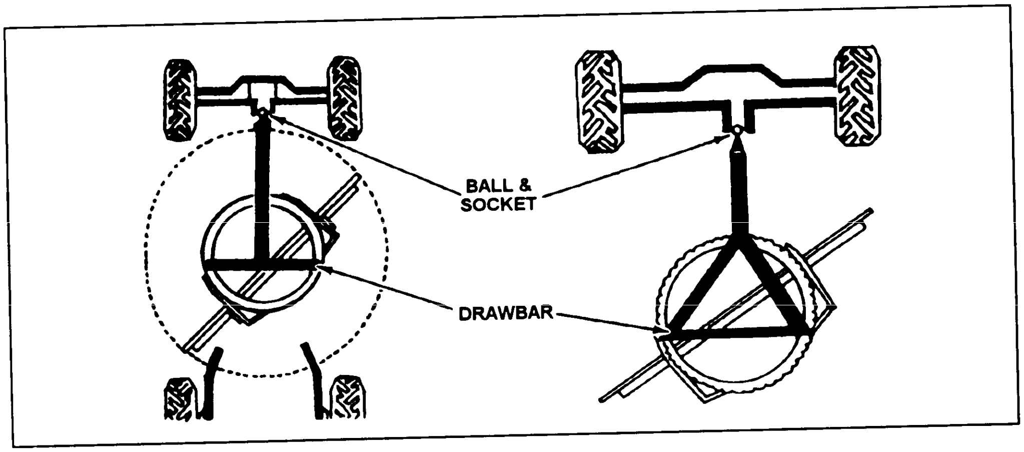


Figure 10-10.-Drawbar.

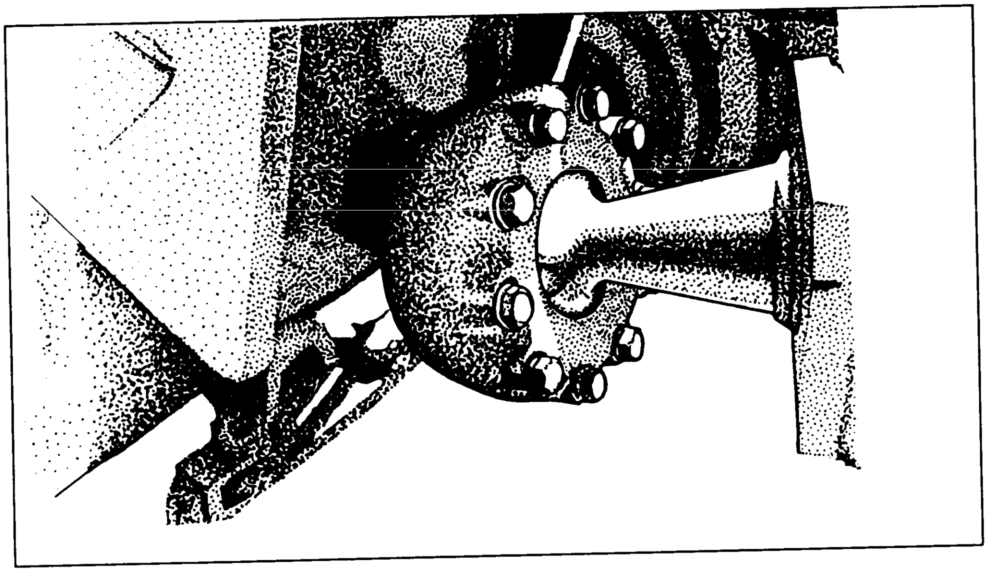


Figure 10-11.-Ball-and-socket connection.

off the heel. When the toe of the blade is to your right, the material will side cast to the left and spill off the heel.

The moldboard is supported and held in position by curved brackets, called **circle knees** and **side shift guides,** as shown in figure 10-6. They are attached to the underside of a rotatable ring, called the **circle.**

Cycle

The circle is a tooth-ring gear that is rotated in a supporting frame by the circle reverse mechanism. The circle teeth may be internal (fig. 10-8, view A) or external (fig. 10-8, view B), depending on the make and model of the grader.

The circle is turned by a spur-pinion gear (fig. 10-9) that meshes with the circle teeth. The spur-pinion gear is held by the **drawbar** and is controlled by a lever in the operator's cab. Engaging the spur-pinion gear allows rotating the circle to the desired blade angle position.

Drawbar

The **drawbar** is a V- or T-shaped connection between the front of the grader frame and the circle (fig. 10-10). The drawbar holds the circle rigid and is fastened by a ball and socket that allows angular movement from side to side and up and down (fig. 10-11). The drawbar carries the full-horizontal load on the blade. Other components provide vertical and side support.

Scarifier

The **scarifier** is a hydraulically controlled unit with a set of teeth used to break up material too compacted

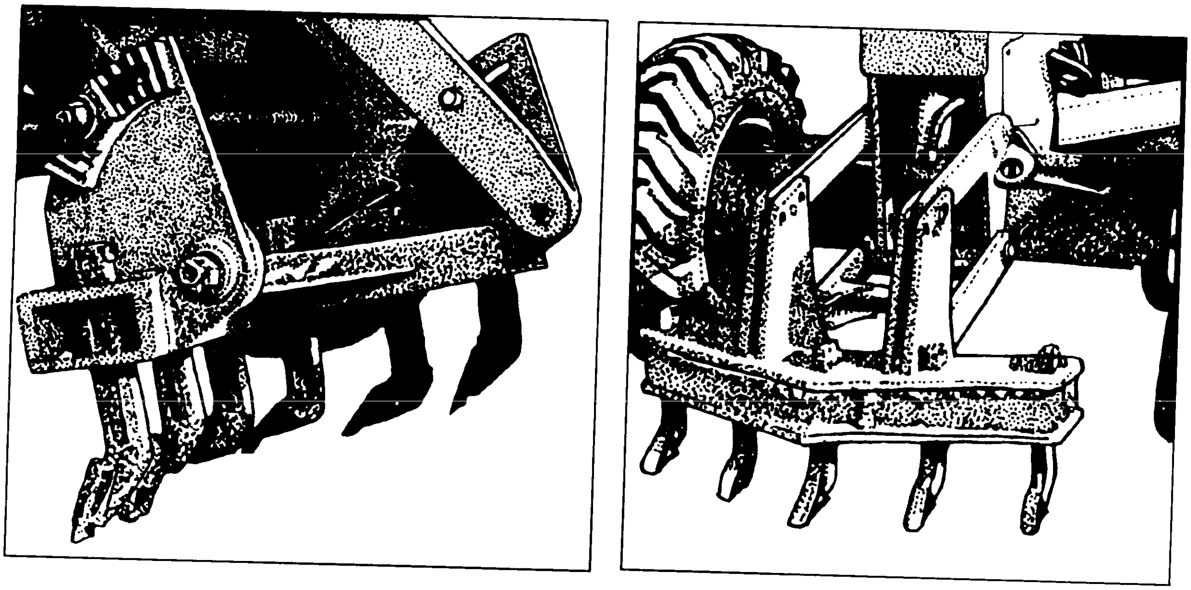


Figure 10-12.-Scarifiers.

to be penetrated by the blade. The scarifier is either pulled or pushed through the material, depending on the make and model of the grader and the position of the scarifier unit on the equipment. Figure 10-12 shows two types and locations of scarifies on graders.

The teeth, consisting of slender shanks with replaceable caps, are set in a V-shaped bar (fig. 10-13). The shanks are wedged or clipped in place and maybe adjusted for height or removed completely.

A scarifier with all the teeth is used for shallow penetration and light work. For hard or deeper penetration, remove every other tooth.

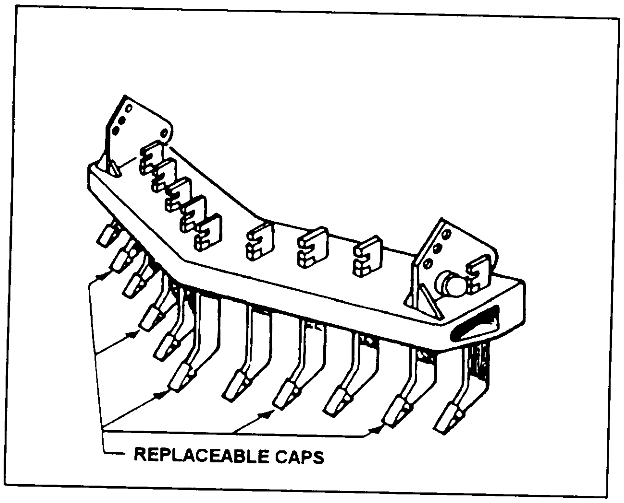


Figure 10-13.-Scarifier teeth.

GRADER OPERATIONS

Although the grader is a multipurpose machine that is capable of doing a variety of jobs, the performance of the grader depends largely upon the skill of the operator. The extensive skill required to perform as an effective grader operator is only gained through practice and on-the-job experience.

Wheel Lean

The proper use of the front wheels is a great aid in both steering and grading. In grading, lean the top of

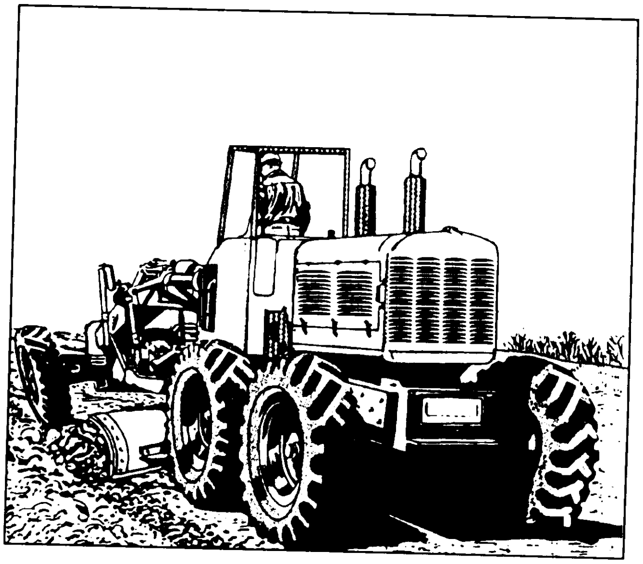


Figure 10-14.-Proper wheel lean.

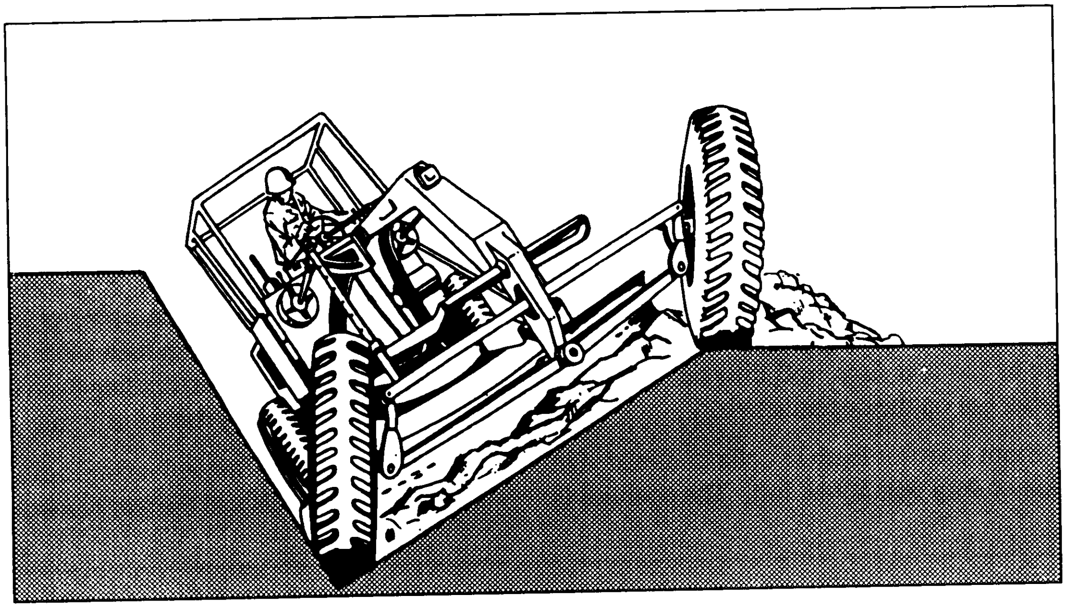


Figure 10-15.-Wheel lean on a ditch slope.

the wheels in the direction of the flow of material (the heel of the blade). For example, as shown in figure 10-14, viewed from the operator's seat, the toe of the blade is extended to the right of the grader side casting the material to the left. The material cut at the toe of the blade causes a pulling force exerted on the front end of the grader, wanting to pull the grader to the right. By leaning the top of the wheels to the left (heel) counteracts this pulling force.

When grading a ditch foreslope, as shown in figure 10-15, lean the top of the wheels enough to keep them in a vertical working position. This will lean technique will do the following: (1) keep the grader from drifting down the bottom of the foreslope and (2) keep the grader wheels from climbing the walls of the backslope.

On high bank-cutting operations, lean the top of the wheels toward the bank, as shown in figure 10-16. The blade engaged in the bank cut causes a pushing force, wanting to push the grader away from the bank. The wheel lean counteracts the force and helps keep the blade properly positioned for bank cutting.

Turning Around

When jobs are confined to short stretches or narrow widths, rotating the blade from forward to reverse grading position requires a circle reverse movement of only about 70 degrees (fig. 10-17). When reverse blading, the cut pass is normally made in reverse, while the side casting of the windrow pass is made on the forward trip, saving valuable time and speed in

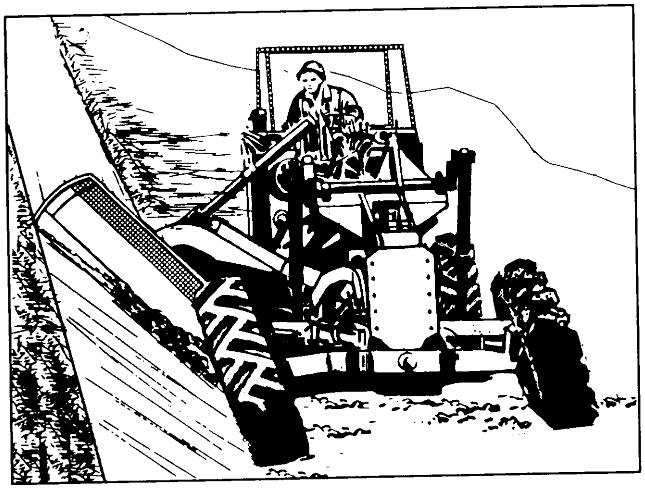


Figure 10-16.—Wheel lean on high bank-cutting operations.

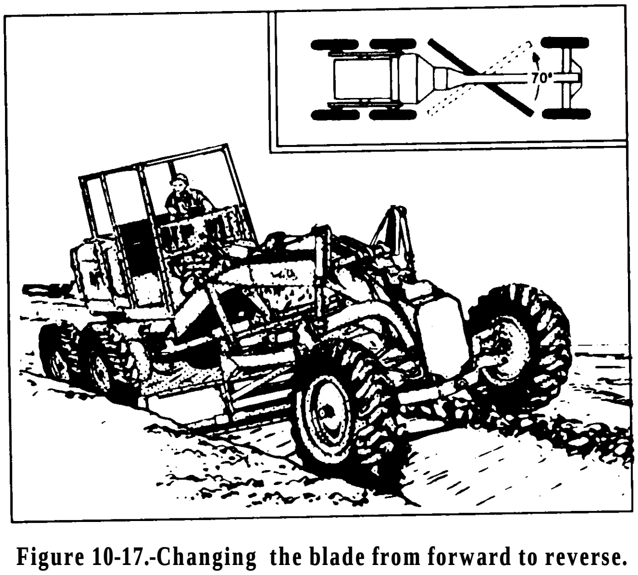


Figure 10-17.-Changing the blade from forward to reverse.

operations by eliminating frequent turning around of the grader.

NOTE: Reverse grading is only for operators who have developed superb skills in grader operations.

For reverse blading, if the scarifier unit is located just in front of the blade (behind the front axle), remove all of the scarifier teeth and fully retract the scarifier unit. This allows a clear area when changing the direction of the blade. When reverse blading, set the blade so the toe is just outside of the rear tires, and the heel side casts outside the front tire on the opposite side.

NOTE: Store scarifier teeth in collateral equipage or in a location so they will not be lost. The operator is responsible for all of the scarifier teeth assigned to the grader.

When you are grading on a project where the passes are less than 1,000 feet, it is more efficient to grade in recerse or vack the grader the entire distance to the starting point than it is to turn around and continue work from the far end, as shown in figure 10-18.

When you are grading on a projuct where the passes are 1,000 feet or more, it is then more efficient to turn the grader around and start blading from the far end back to the starting point, as shown in figure 10-19.

The combined maneuvering advantages of the leaning front wheels and the rear tandem drive are a big

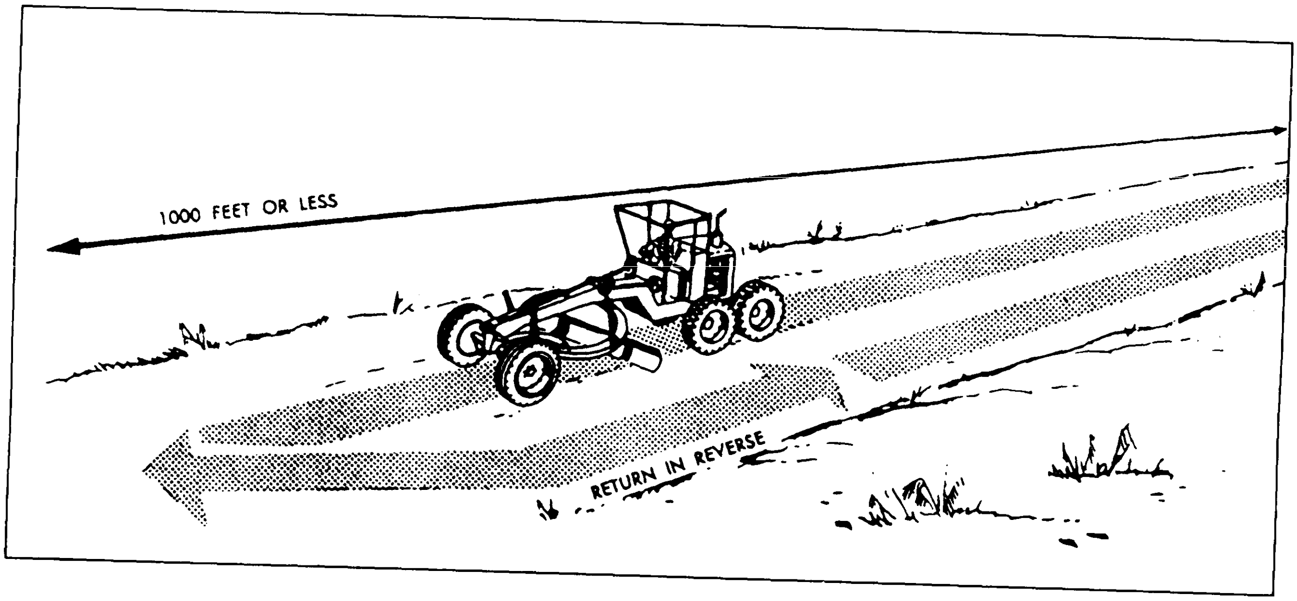


Figure 10-18.-Elinimate unproductive turning around.

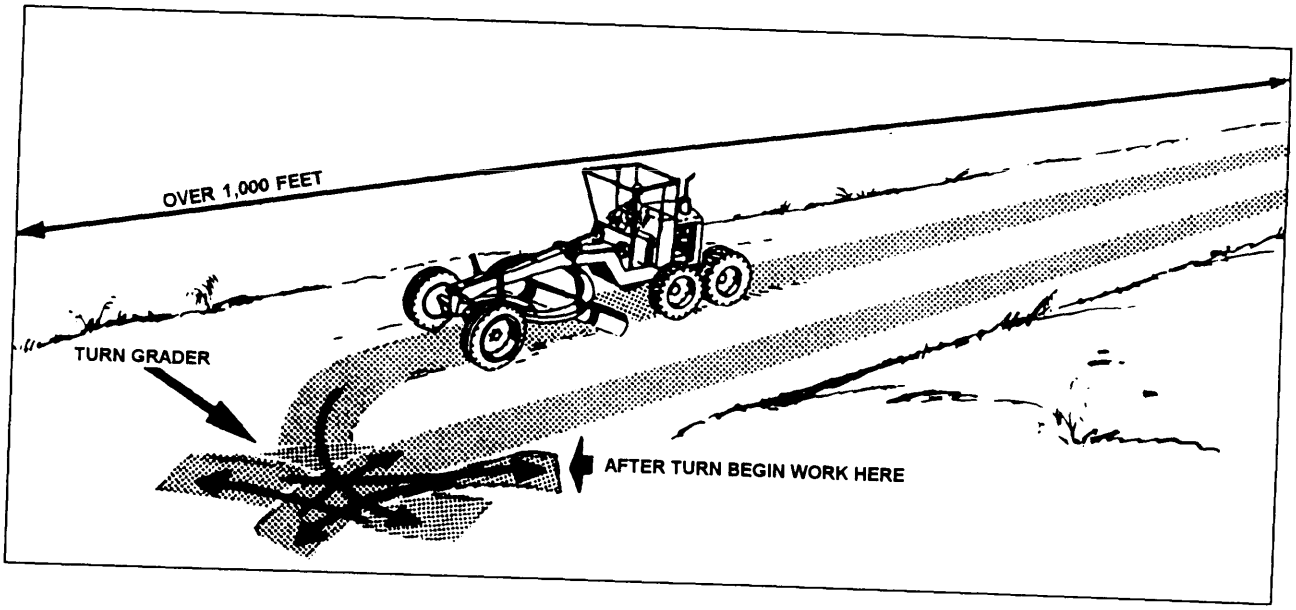


Figure 10-19.-Turning around.

help in turning the grader around on a construction project. Figure 10-20 shows a simple technique to turn the grader around. With the wheels leaned in the direction of the turn (A), back across the ditch (B), and then complete the turn (C). By keeping the front wheels on the roadway and leaning the wheels in the direction of the turn, you can make the grader turn with ease.

NOTE: Always back across the ditch and leave the front wheels on the roadway.

Blade Pitch

The blade pitch adjustment is a working tool that supports the cutting action of the blade and is hydraulically controlled by a lever in the operator's cab. Figure 10-21 shows the different blade pitch adjustments.

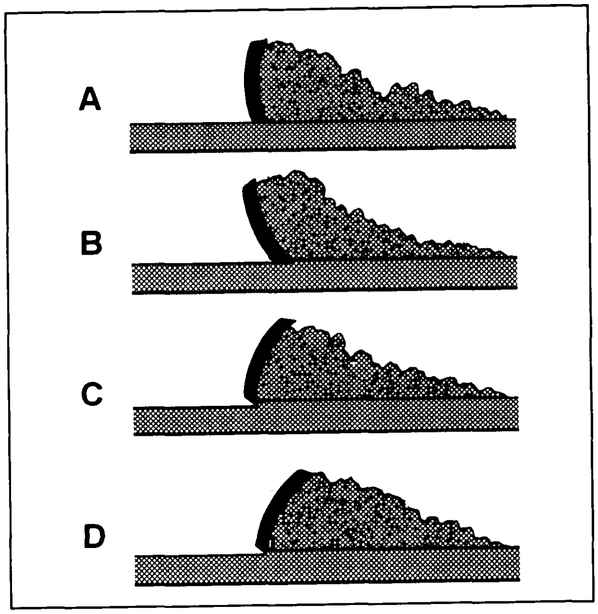


Figure 10-21.—Blade pitch.

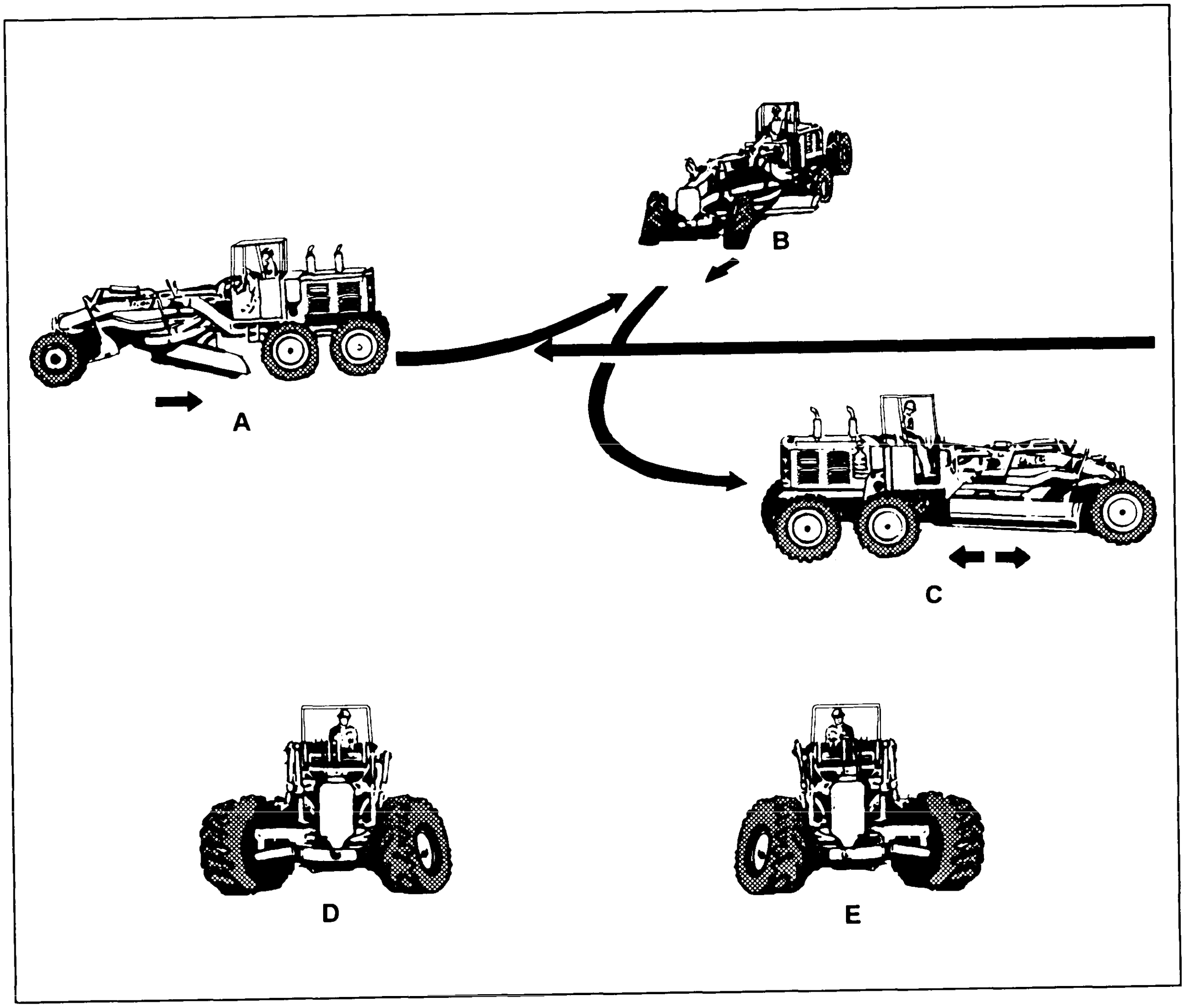


Figure 10-20.—Turning the grader around technique.

For normal grading operations, the upright position on the blade is used. For a greater cutting action, the backward pitch is used. For a greater mixing and rolling action on the material being side tasted, use a slight forward pitch. When spreading, finishing, or maintaining surface material, use a full forward pitch. This pitch accomplishes a partial compaction of the surface materials and assures filling any low spots.

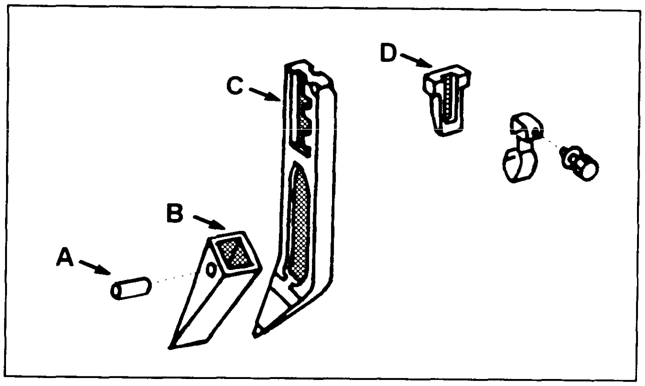
When selecting the correct blade pitch, you have to think about the type of operation, type of material, depth of cut, and speed of operation. Experience and practice enhance your skills to know which pitch positions achieves the best blading results for the type material.

Scarifying

Scarifying is breaking up hard or compacted materials, using the scarifier on the grader. A decision to scarify a road or not depends on the availability of water to obtain the proper moisture content of the material and the amount of traffic that travels the road. The proper moisture content supports the binding of the material required for compaction and is also used as dust control.

Just placing fill material on a dirt road to fill the ruts and potholes is a temporary fix. The fill material does not bind in the ruts and potholes and, therefore, will NOT remain in place.

The proper way to reshape a dirt road full of ruts and potholes is to scarify the surface to the depth of the depressions. This breaks up all the compacted surrounding surface materials. After scarifying the material, blade mix the surface materials, reshape the road, and compact.



A. Pin
B. Cap
C. Shank
D. Lock Wedge

Figure 10-22.—Scarifier tooth.

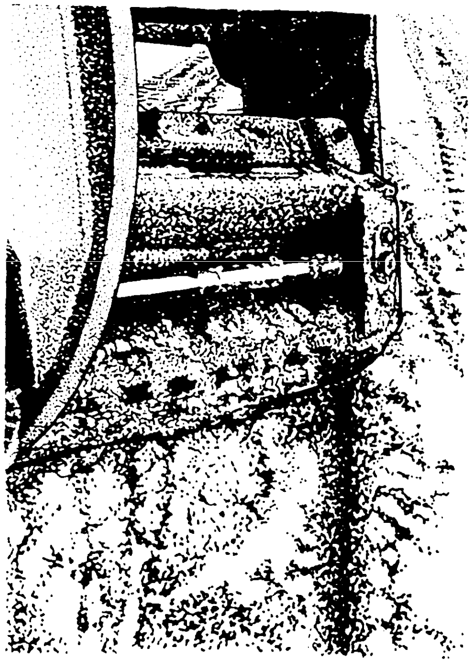


Figure 10-23.—Marking cut.

To scarify extremely hard or consolidated material, remove alternate scarifier teeth. This will ease passage of the scarifier through the material.

CAUTION

Never make sharp turns with the scarifier teeth in the ground. Making sharp turns damages the scarifier and possibly bends or breaks the teeth.

During prestart operations, check the scarifier teeth for wear. When the caps are worn enough to cause damage to the shank, replace the cap (fig. 10-22).

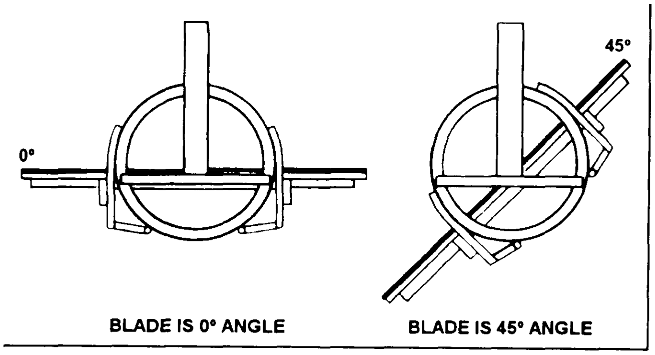


Figure 10-24.—45-degree position of the blade.

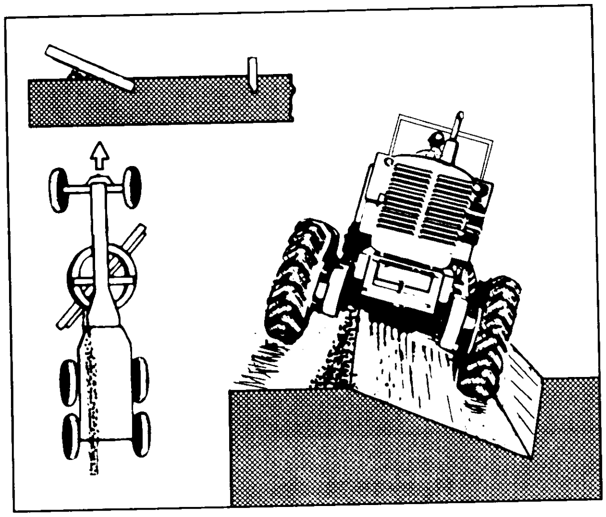


Figure 10-25.-Ditch cut.

Ditch Cut

The first step performed on a road project is to establish drainage normally through the use of a ditch. To construct a ditch, you must know how to cut a straight ditch line and make sure the ditch line stakes fit the plans.

The first cut to make is the **marking cut.** The marking cut is a 3- to 4-inch-deep cut made with the toe of the blade (fig. 10-23). The toe of the blade is positioned in line with the outside edge of the front tire. For cutting, the blade pitch is adjusted until the top and bottom edges of the moldboard are aligned Perpendicular to the ground. The marking cut is a technique used for easier grader control and straighter ditches.

After the marking cut, position the blade at about a 45-degree angle to perform an efficient **ditch cut** (fig. 10-24). The toe of the blade is positioned in line with the center of the lead tire, while the heel of the blade is raised to allow the windrow to form either inside or outside the rear wheels (fig. 10-25). It maybe necessary to remove the scarifier teeth to keep them from interfering with the blade.

NOTE: Do not forget to lean the top of the front wheels in the direction of the flow of the cut material.

After each ditch cut, the material should be windrowed or spread towards the middle of the road, away from the ditching operations. This technique is called **shoulder pickup.** To spread the windrow away from the ditch, position the front grader tire on the inside of the windrow. Side shift the blade and the circle so the toe is positioned to the outside of the windrow, as shown in figure 10-26. The heel is positioned to allow the windrow to side cast inside the rear tandem tires. The purpose of the shoulder pickup is to move the windrow away from the foreslope of the ditch.

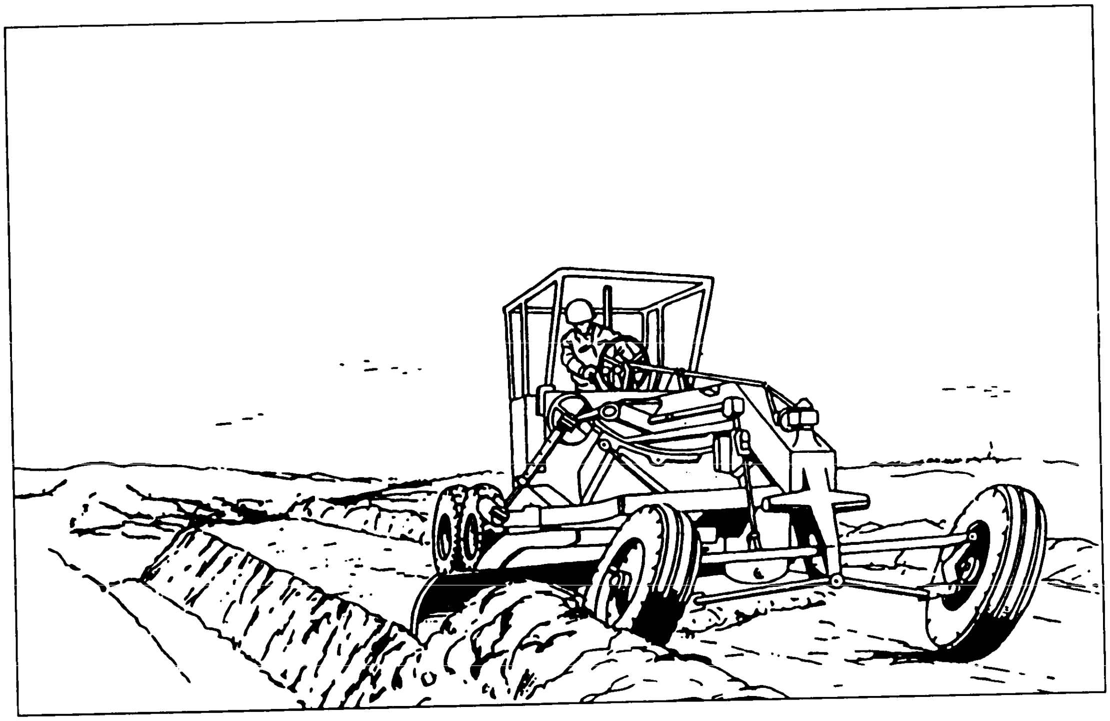


Figure 10-26.-Shoulder pickup.

The next pass to make is the **spreading pass** (fig. 10-27). The blade and circle are shifted back under the grader frame. While the grader straddles the windrow, the toe of the blade is positioned inside the front tire, and the heel is positioned to side cast the material outside the rear tandem tires. Depending on the amount of material, the spreading operation may require several passes. After spreading the material, the ditch cut, shoulder pickup, and spreading pass are performed until the desired depth of ditch is completed.

When the backslope of the ditch needs to be cut (fig. 10-28), position the circle and the blade with the heel resting at the bottom of the foreslope, so the material flows inside the right rear tandem tires. The toe of the blade should be forward toward the right front tire. The top of the wheels is leaned toward the backslope.

When the ditch is to have a plain V-bottom, you now have to perform a clean-up pass on the foreslope to remove the material from the backslope cut. After the foreslope is clean, perform a shoulder pickup and a spreading pass to finish the ditching operations.

Flat-Bottom Ditch Cut

When a flat-bottomed ditch is required, proceed as follows:

Starting at the foreslope of the original V-ditch (A), as shown in figure 10-29, use the ditch-cutting procedures to cut another V-ditch. After the V-ditch is completed, the next step is to make a flat cut in the bottom of the ditch. This is performed by placing the complete length of the blade in the ditch. The toe is positioned at the base of the backslope (B), and the heel is positioned to side cast the windrow inside the rear tandem tires (C). This operation moves the material to the foreslope of the second V-ditch. To remove the material from the foreslope, perform the procedures used when removing material from a V-ditch.

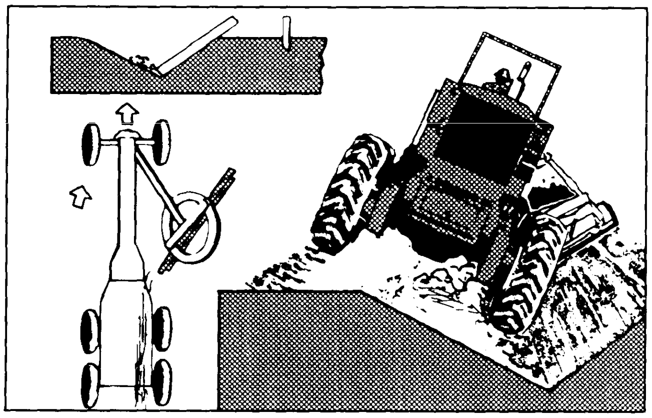


Figure 10-28.-Backslope cut.

Crown

The **crown,** or slope, of the road from the centerline of the road toward the shoulders provides drainage to the ditch. For crowning, angle and adjust the blade to conform to the specified angle of the crown. The material is side tasted in windrows from the shoulders of the road up toward the center line.

When the road has a ditch on each side, make the first pass down the length of one shoulder. When the length of the pass warrants, turn around and proceed down the length of the opposite shoulder with the blade

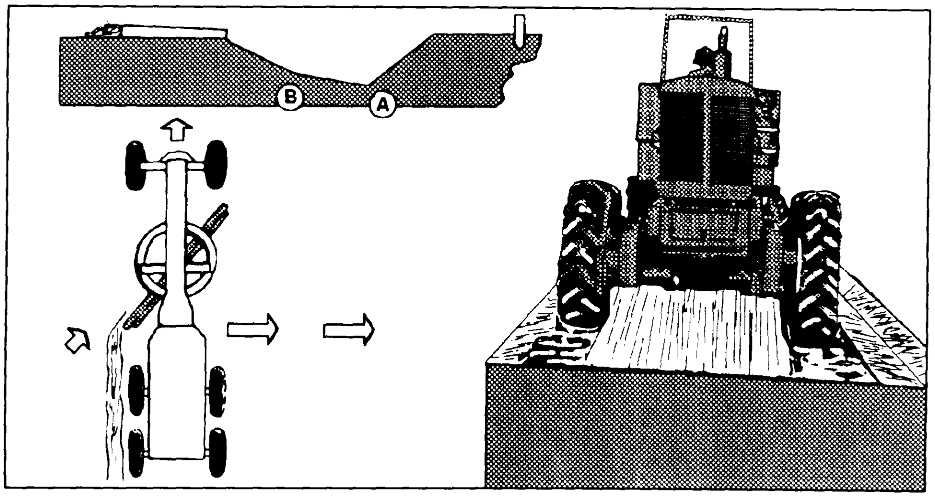


Figure 10-27.-Spreading pass.

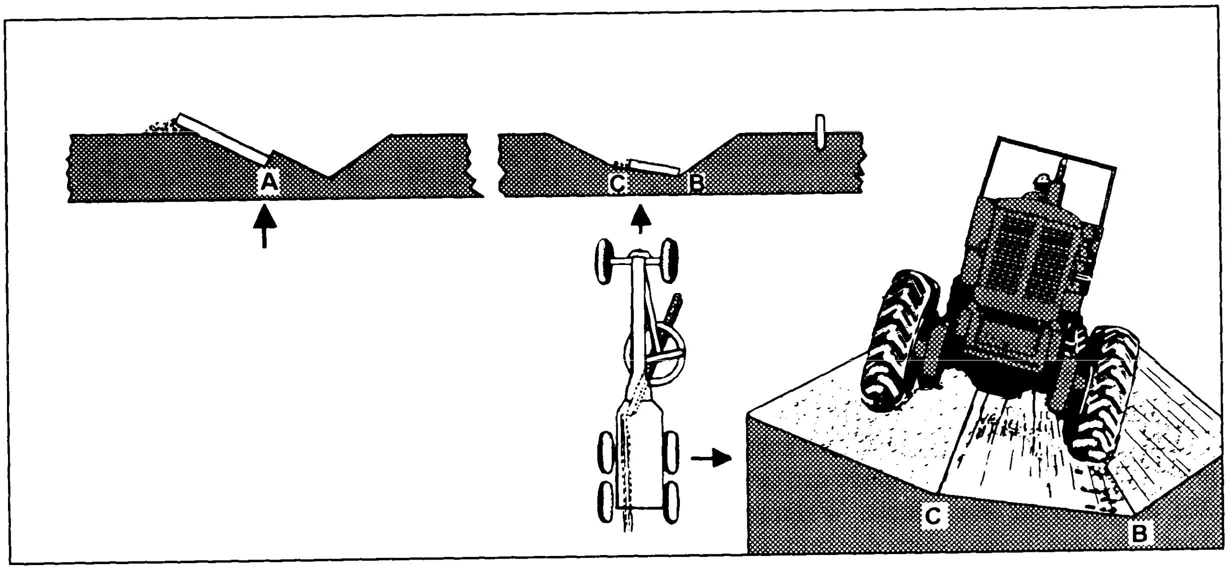


Figure 10-29.—Flat-bottom ditch cut.

Adjustment relative to the same position. When the distance is too short, backup and start on the opposite shoulder with the opposite blade angle adjustment. By repeating overlapping passes made in this manner, you can side cast two windrows from the shoulders to the center line where they are combined into one. The center windrow is then spread with the blade set at 0 degrees. Material spill around the blade ends is spread evenly among the slope of the crown.

NOTE: When grading, the operator cannot obtain a full-visual view of a project site from the operator's seat. For this reason, the operator should stop and climb off the grader periodically to take a visual look at the work area to determine work progress and areas that need attention.

High Bank Cuts

High bank cuts are used to cut or trim slopes on ditches, deep cuts, and high fills. The circle and blade are positioned vertically on the side of the grader. The toe of the blade is angled forward of the heel.

NOTE: Read the operator's manual for the type of grader you are operating to receive instructions on setting up the circle and blade for high bank-cutting operations.

When performing high bank cuts, lean the top of the front wheels towards the bank or slope. Move the grader into position and set the blade on the slope (fig. 10-30). When cutting, make light cuts with the toe of the blade. The heel of the blade does not require many adjustments. When too much down pressure is placed on the blade, you will lift the side off the grader or cut a gouge in the slope. After the high bank cut is performed, clean the cut material from the base of the slope, using the ditching technique.

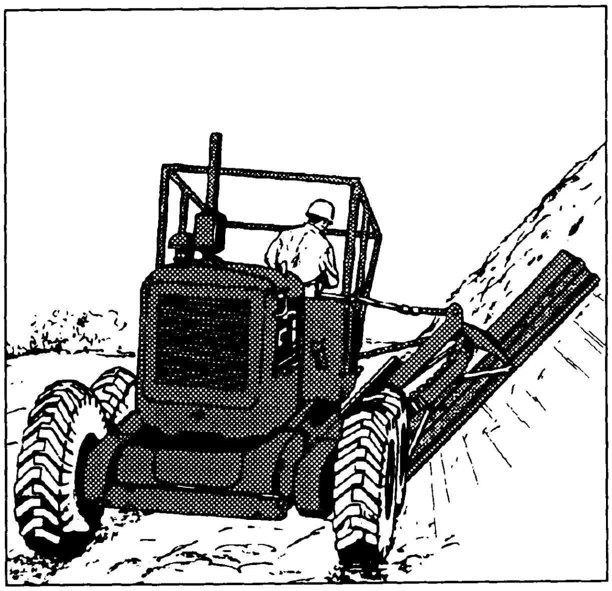


Figure 10-30.-High bank cut.

Wide Side Reach (Spreading)

A grader may be used in spreading piles of loose material. When there is space to work around the pile, the blade should be extended well to the side and angled to side cast the windrow to the inside of the rear tires. The pile is reduced by using a series of side cuts, as shown in figure 10-31. Piles to be spread by a grader should be spread dumped as much as possible. The load to be spread is limited by the power and traction of the grader.

When there is not enough room to use the wide side reach and the piles of material are not too high, the front wheels may be driven over the piles. The front axles push the top off the pile, and the blade cuts as much as power permits. The blade should be positioned well below its highest point, so when the grader gets hung up on the piles and loses traction, the blade can be raised to restore the weight to the rear wheels. When traction is lost and the tires spin, unnecessary tire wear increases.

Road Maintenance

The ability of the grader to blade mix materials used as road surfaces is an important function in road maintenance. When blade mixing, pitch the blade slightly forward and angled at about 30 degrees. This position gives the widest possible spread with maximum mixing action. In mixing, move the windrow from side to side by successive cuts with the blade.

To increase production, use several graders to operate, one behind another, on the same windrow (fig. 10-32). When the mixture is wet, mixing should continue until the mixture is dry. After mixing, the material is again side tasted into a windrow before spreading. During mixing, more bitumen or cement can be applied to any lean sections. All particles of the completed mix should be coated and uniform in color.

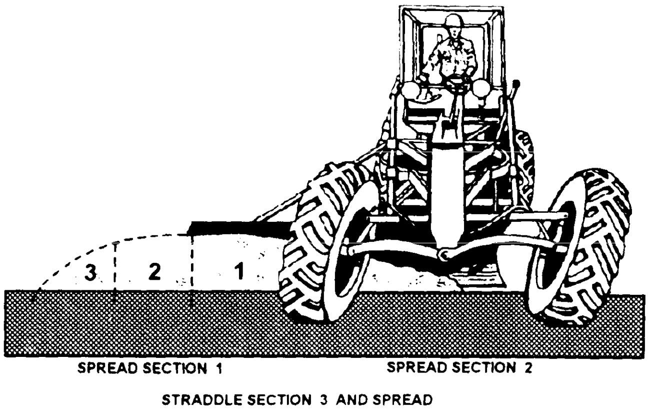


Figure 10-31.—Wide side reach.

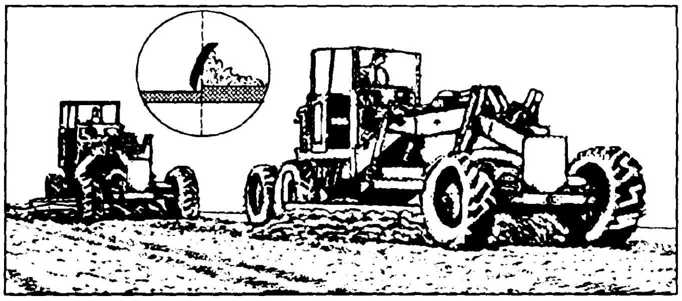


Figure 10-32.—Blade-mixing operation.

Blade-mixing operations are performed as rapidly as possible, consistent with the skill of the operator and the condition of the surface being maintained. However, when the grader is operated too fast, it will tend to bounce and give the surface a washboard appearance that will take additional time and passes to connect. When washboarding is not corrected, it will create unnecessary wear and tear on traffic using the road or work area.

Snow Removal

Graders can be used for snow removal in the same way as a snowplow. The blade and circle are adjusted to side cast snow and slush the same as if side casting road materials. When the cutting edges are not removed and replaced with a strip of hard rubber bolted to the moldboard, raise the blade at least 1/2 to 1 inch when removing snow from uneven pavement or a runway surface.

NOTE: Failure to make proper blade adjustments can result in not only damaging the cutting edges, moldboard, or grader, but also in gouging and tearing up the road or runway surface.

Finish Grading

Finish grading is a fine cut or fill of a surface to get the final desired elevation. This phase of a grading operation is called **blue topping.** Blue topping takes time and patience even for experienced operators.

When performing blue topping operations, make sure the grader cutting edges are not worn, the tires are the same size with the correct air pressure, and the tires are pointed in the right direction. Front tire treads should be pointed toward the rear, and rear tire treads should be pointed toward the front. Adjust the blade pitch all the way forward to scrape instead of cut.

Before making any cuts on a project, review the project grade hub stakes (blue tops) to note their location and how much you will have to cut or fill.

NOTE: Compaction of the surface must be done before finish grading can start. When you finish grading, it is better to cut 1/2 to 1 inch than to fill.

A technique used when performing blue topping operations is to divide the project into sections, working one section to final grade at a time. After the first section is to grade, you now have a reference point to start from to grade the other sections. As with any earthmoving equipment, it is best to have a level starting point.

When working each section, do not let the material build up into piles that the grader will have to run over. Windrow the material to the end or off the section and have a loader pickup the excess material and move it. If there is room, the excess material can be windrowed off the project for later removal.

When cutting, drag the blade over the top of the hub stake. Final grade is reached when the blade skims the top of the hub stake. Do not cut too deep and knock the hub stake out of the ground. When several passes are required to achieve final grade, the "cut boss" should clean off the top of the stakes so you can see them for your next pass.

Grader Estimates

A part of planning a construction project is estimating how long it will take to complete a construction activity. A work-output formula for preparing preliminary estimates for grader operations is as follows:

$$\text{Total time} = \frac{P \times D}{S \times E}$$

Where

Total time = Hours required to complete a grader operation

P = Number of passes (P) the grader must take to complete the operation

D = Distance (D) traveled in each pass expressed in miles

S = Speed (S) expressed in miles per hour

E = Grader efficiency (E) factor

The most difficult factor to estimate is the speed of the grader. As work progresses on a construction activity, conditions may require that the speed estimates of the grader be increased or decreased. A work output is computed for each operation that is performed at a different rate of speed. The total time of each operation for each different speed is added together to compute the total time of the grader operation. Table 10-1 lists the speeds normally used in various grader operations.

The grader efficiency (E) factor takes into account the fact that a 60-minute work hour rarely is attained. Efficiency varies, depending upon supervision, operator skill, maintenance requirements, and site conditions. A value of 60 percent is average, computed in decimal form as 0.6. The efficiency factor can be adjusted on each job.

Example problem:

Five miles of gravel road is to be leveled and reshaped by using a grader with a 12-foot blade. Six passes are estimated to complete the leveling and reshaping operation. The type of material permits passes 1 and 2 to be performed in second gear at 2.8 mph, passes 3 and 4 in third gear at 3.4 mph, and passes 5 and 6 in fourth gear at 5.4 mph. The efficiency factor for the job is 60 percent.

Calculate how long it will take to complete the job.

$$\textit{Total time for passes } 1 \textit{ and } 2 = \frac{2 \times 5}{2.8 \times 0.6} = \frac{10}{1.68} = 5.90 \textit{ hours}$$

$$\textit{Total time for passes } 3 \textit{ and } 4 = \frac{2 \times 5}{3.4 \times 0.6} = \frac{10}{2.04} = 4.90 \textit{ hours}$$

$$\textit{Total time for passes } 5 \textit{ and } 6 = \frac{2 \times 5}{5.4 \times 0.6} = \frac{10}{3.24} = 3.08 \textit{ hours}$$

$$\textit{Total time of the project} = 5.9 + 4.9 + 3.08 = 13.88 \textit{ hours}$$

Always round your answer to the next higher number. In this case, 13.88 is rounded to 14 hours.

Table 10-1.-Approximate Speed Ranges Used in Various Grader Operations

OPERATION	SPEED (MPH)	OPERATION	SPEED (MPH)
MAINTENANCE	3 TO 10	BANK SLOPING	2
SPREADING	3 TO 6	SNOW REMOVAL	10 TO 15*
MIXING	5 TO 15	FINISHING	3 TO 5
DITCHING	2-TO 3		

*EXCEPTION TO MAXIMUM SPEED PERMISSABLE ON HIGH TYPE RUNWAYS AND HIGHWAYS.

GRADER SAFETY

Safety precautions that apply to graders are as follows:

- Keep hands, feet, and clothing away from power-driven parts.

- Clothing worn by the operator should be relatively tight and belted. Do not wear loose jackets, shirts, sleeves, or other items of clothing because of the danger of catching them in moving parts.

- Before starting the engine, always check the service brakes and the parking brake to ensure they are in proper working condition.

- Do not use the steering wheel as a handhold when getting on and off the grader.

- Keep hands, floors, and controls free from water, grease, and mud to ensure nonslip control.

- Never attempt to start or operate the grader except from the operator's station.

- Always keep the grader in gear when going down steep hills or grades.

- When transporting or driving on a road or highway at night or during the day, use accessory lights and devices for adequate warning to the operators of other vehicles. In this regard, check local government regulations.

- Never drive too close to the edge of a ditch or excavation.

- Do not leave the engine running while making adjustments or repairs unless specifically recommended.

- Never refuel when the engine is running. Do not smoke while filling the fuel tank or servicing the fuel system.

- Never leave the grader unattended with the engine running.

- Do not oil, grease, or adjust any part of the grader while it is in motion.

- Check for faulty wiring or loose connections.

- Keep a firm grip on the steering wheel at all times when speed is increased.

- Do not allow anyone near the grader while the driver is in the seat with the engine running.

- Reduce speed before turning or applying brakes. Drive at speeds slow enough to ensure your safety, especially over rough ground.

- Do not operate the grader so fast on hillsides or curves that you may tip over.

- When you are operating your grader, be sure your path ahead is clear to avoid collision with other equipment.

- Watch for overhead wires. Never touch wires with any part of the grader.

- Do not use the grader as a battering ram.

- Keep the working area as level as possible.

- Never allow anyone to work under a raised blade or other attachment.

- Do not leave the blade or other attachment in the raised position when it is not in use. Always lower it to the ground.

- Be sure bystanders are clear of the grader before lowering or moving the blade.

- Park the grader on level ground or across the slope.

- Remove all trash accumulation from the engine and the operator's station daily.

- Wear any required personal protective equipment.

SCRAPERS

Scrapers are designed for self-loading, hauling, and spreading material on long-haul earthmoving operations. Scrapers are most efficient when operated in light and medium materials that are nearly free of roots, stumps, and boulders. Heavy or consolidated materials require ripper-equipped dozers to rip open the surface and assist loading operations by pushing the scraper through the cut to achieve maximum loading. The dozer pushing the scraper is referred to as a push cat.

Scrapers are built with open tops to make them suitable for loading by crane clam shell, conveyor, or front-end loader. The types of scrapers used in the NCF are equipped with either a single engine or twin engine (fig. 10-33). On twin-engine scrapers, the one engine in the front is used to pull, and the one in the rear is used to push.

Another type of scraper used in the NCF is the paddle wheel scraper (fig. 10-34), also called the

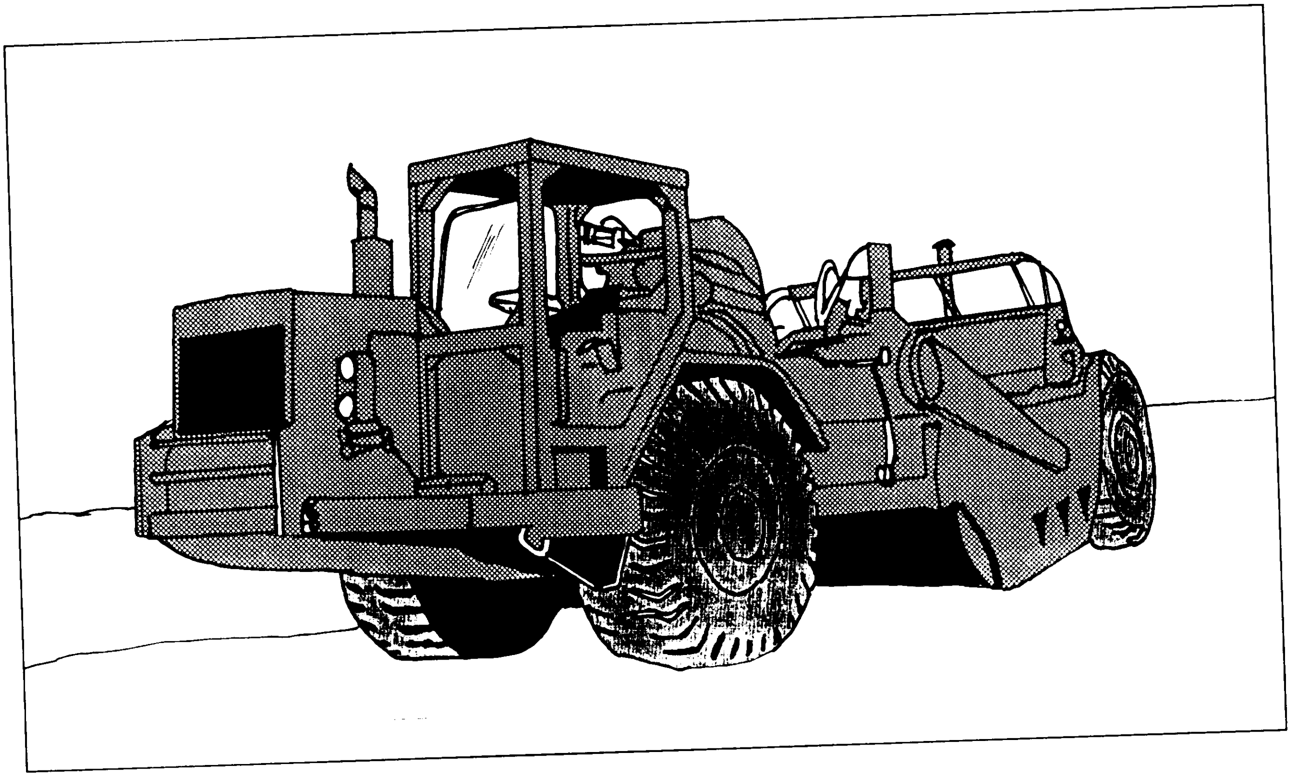


Figure 10-33.–Scraper.

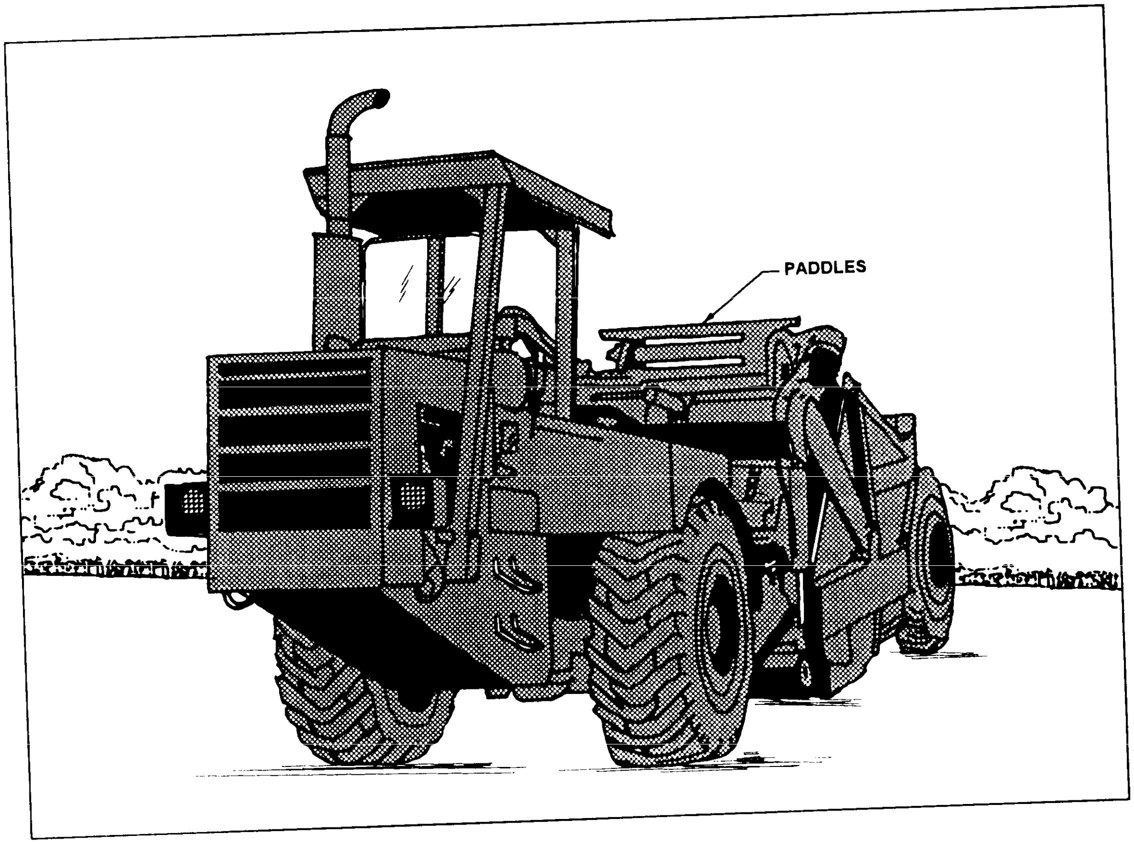


Figure 10-34.—Paddle wheel scraper.

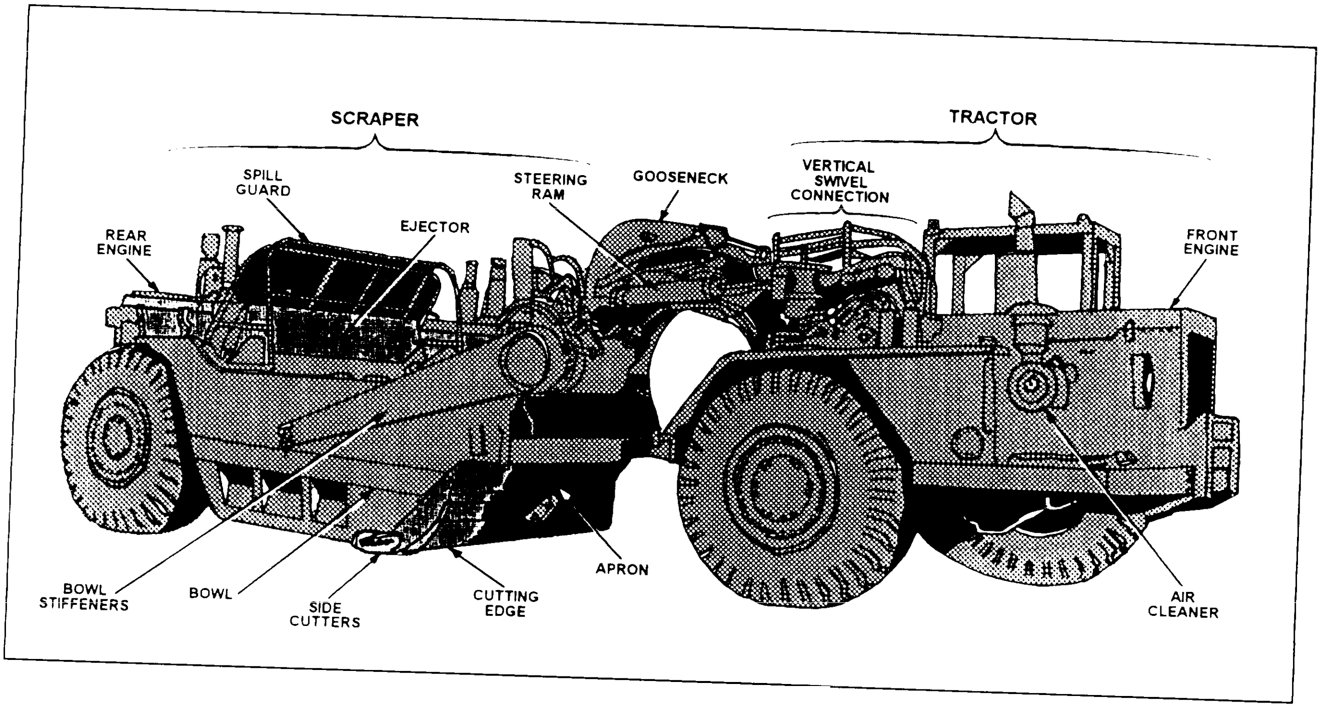

SCRAPER
TRACTOR
SPILL GUARD
STEERING RAM
GOOSENECK
VERTICAL SWIVEL CONNECTION
REAR ENGINE
EJECTOR
FRONT ENGINE
APRON
BOWL STIFFENERS
BOWL
SIDE CUTTERS
CUTTING EDGE
AIR CLEANER

Figure 10-35.—Scraper nomenclature.

elevating scraper or self- loading scraper. This scraper, on most projects, requires no push cat for loading and is ideal for small- to medium-size earthmoving jobs. The scraper loads its pan from the top by means of a paddle wheel elevator after the material has been cut by the cutting edge. Material is not forced to the top as on other scrapers. The loaded material can also be unloaded by the paddle wheels, giving the operator more control of the desired depth of fill.

A variety of scrapers are used in the NCF. Each operator is responsible for reading the operator's manual to obtain detailed information about each make and model.

SCRAPER COMPONENTS

The scraper is made in two sections: the tractor and the scraper. The tractor contains the engine, the drive train and wheels, the hydraulic pumps, and the operator's cab. The tractor is connected to the scraper by a vertical kingpin swivel connection usually in two parts with upper and lower pins. When you are steering, this connection permits turns of 85 to 90 degrees to each side of the center line of the scraper. There is also a longitudinal horizontal hinge that permits the two sections to tip independently from side to side.

The gooseneck of the scraper arches up to allow space for the tractor wheels to roll under it on turns. The

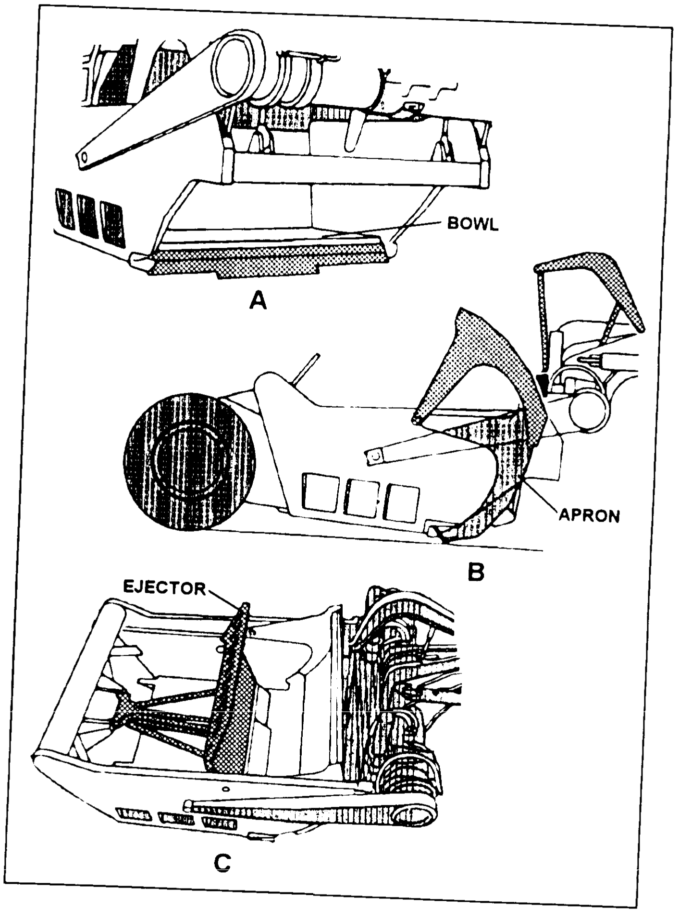

BOWL
A
APRON
B
EJECTOR
C

Figure 10-36.—Scraper bowl, apron, and ejector.

gooseneck then widens into a very massive crossbeam becoming a pair of side arms extending backward to the trunnion fastenings on the sides of the scraper bowl.

The gooseneck carries the steering cylinders, the lift cylinder and lever arm for the apron, and a pair of hoist cylinders for the bowl. Scraper nomenclature is shown in figure 10-35.

A scraper has three basic operating parts: the bowl, the apron, and the ejector.

Bowl

The bowl (fig. 10-36, view A) is a box with rigid sides, with the apron as a movable front, and the ejector as a movable back. The forward edge of the bowl is fitted with cutting edges. The cutting edges are made of wear-resistant steel and are bolted to the bottom of the bowl. The three main cutting edges areas follows:

1. The straight cutting edge is the most efficient for smooth finish grading.

2. The curved cutting edge penetrates more than the straight edge.

3. The three-piece cutting edge has the center piece positioned ahead of the two side pieces for deeper penetration. The center piece is referred to as the stinger (fig. 10-37).

The bottom front sides of the bowl usually have bolted-on wear plates called side cutters. The side cutters normally receive less wear than the cutting edges.

NOTE: Cutting edges that are worn or damaged should be replaced to prevent wear of the scraper bowl.

Apron

The apron (fig. 10-36, view B) forms the forward section and a variable amount of the bottom of the bowl assembly. When closed it rests at the cutting edges. The apron is hydraulically controlled by a lever in the operator's cab. When the apron is lifted, it moves upward and forward far enough to leave the whole front of the bowl open.

Ejector

The ejector is the rear wall of the bowl (fig. 10-36, view C). The most common ejector is hydraulically controlled and moves forward horizontally, forcing the load out of the bowl. It is supported by rollers riding on the floor and on tracks welded to the sides of the bowl.

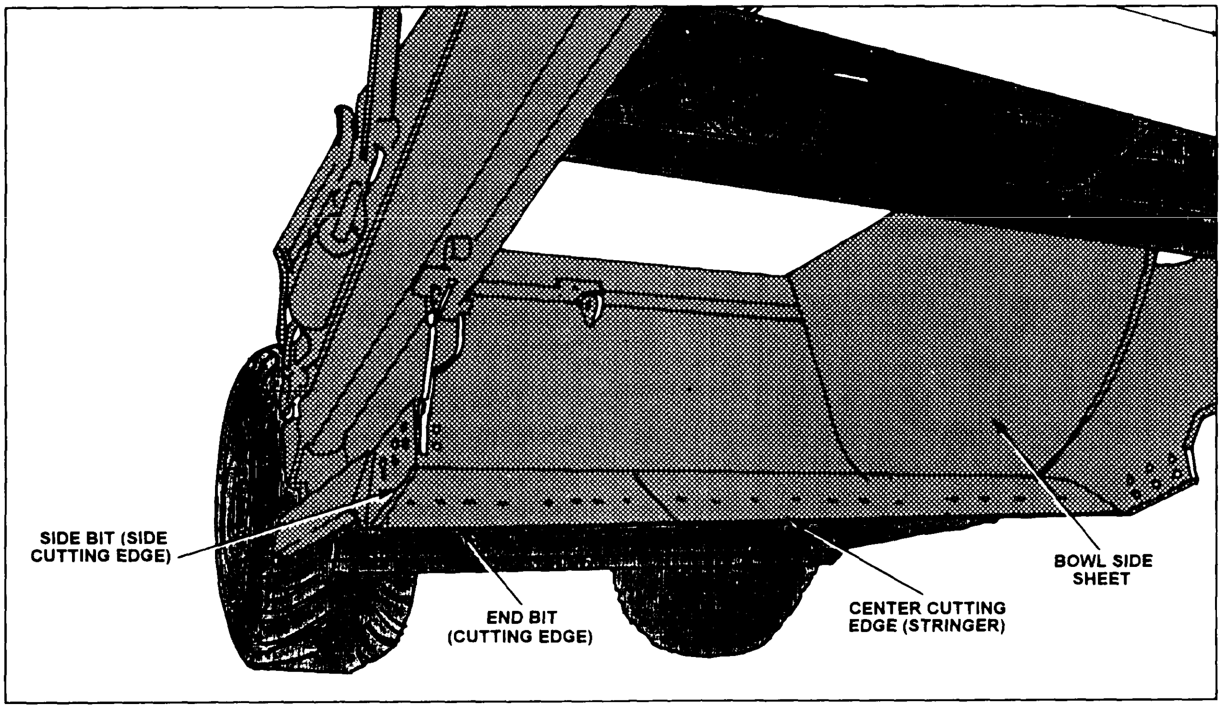


Figure 10-37.-Scraper cutting edges.

CONTROL LEVERS

Most scrapers have three basic control levers located on the right side of the operator's seat. The first lever is the **bowl lever** (fig. 10-38, view A). The bowl lever raises and lowers the bowl. The middle lever is the apron **control lever** (fig. 10-38, view B). The apron control lever opens and closes the apron, allowing the required amount of material to enter or be ejected from the bowl. The third lever is the **ejector lever** (fig. 10-39, view C). The ejector lever forces the dirt out of the bowl. For maximum hydraulic cylinder operating efficiency, the engine should be operated at maximum rated speed and the control levers moved to their extreme operating position.

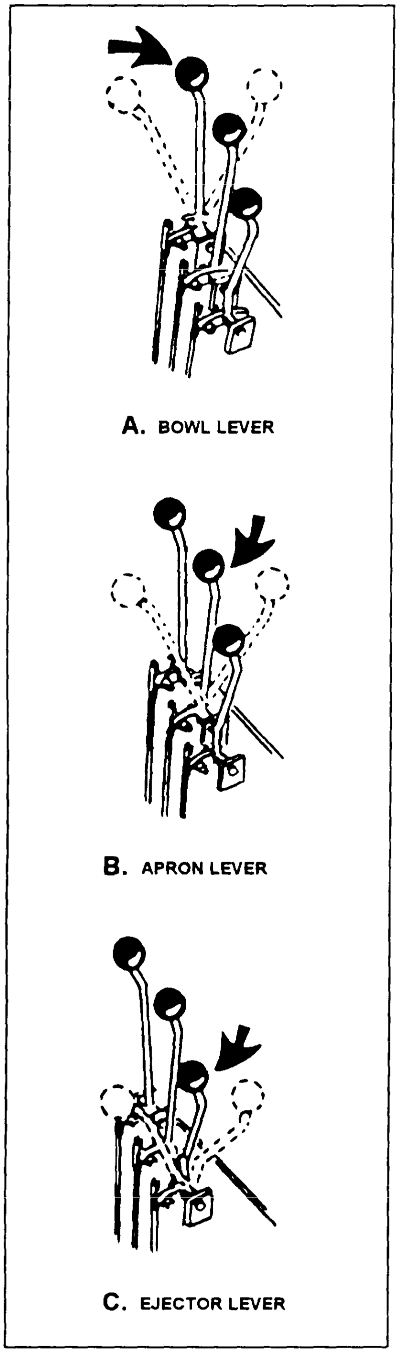


Figure 10-38.-Scraper control levers.

SCRAPER OPERATIONS

The greatest engine power is available when the engine is running at top governed speed. The proper transmission gear ratios must also be engaged to obtain maximum engine power output. When the transmission is placed in a too high a gear ratio for full engine power, the result is a **stall** condition in the transmission converter. Stalling the converter prevents the engine from operating at maximum efficiency and results in rapid overheating and premature wear of the converter or transmission.

The transmission must be downshifted correctly while the scraper is in motion to prevent damage to the power train. Improper downshifting overspeeds the transmission and engine and usually results in premature wear and unnecessary transmission breakdowns.

When moving the scraper from a full stop, always start with the transmission in low gear, depressing the throttle for the degree of acceleration required. A wide, open throttle provides the fastest acceleration under full-load conditions.

When running downgrade, avoid overspeeding the engine by keeping the scraper speed at, or below, the maximum speed for the transmission range engaged. As a general rule, downhill scraper speed should not exceed 5 mph more than that attained on level ground in the transmission ratio engaged.

When the selected transmission ratio is too high, slow the scraper with the service brakes until the transmission can be properly downshifted to the required range for the grade.

Downhill speed can be slowed, if necessary, by lowering the scraper bowl until the cutting edge drags enough to slow the scraper to the required speed to permit proper downshifting or stopping.

Do not **fan** the brakes by repeated depressing and releasing. This practice can reduce air pressure below the point required for proper breaking. The air pressure system should indicate 105 to 125 psi on the air pressure gauge for effective braking. When the gauge indicates a pressure drop below 105 psi for a long time, shutdown the scraper until the trouble is corrected.

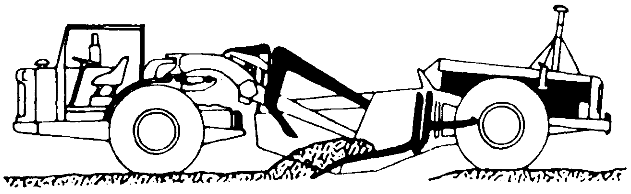


Figure 10-39.-Entering the cut.

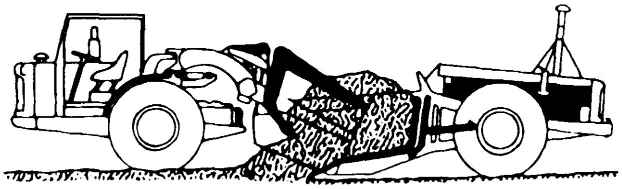


Figure 10-40.—Loading the bowl.

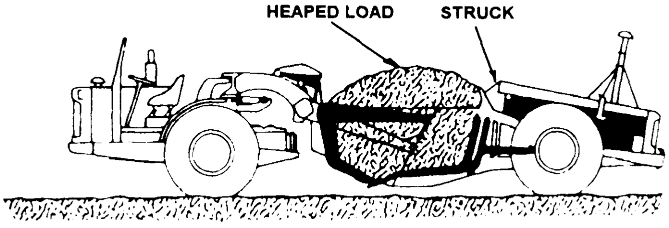


Figure 10-41.-Loaded bowl.

The scraper work cycle has four phases of operation: loading, hauling, spreading or unloading, and returning to the cut.

Loading

When loading, enter the cut with the ejector positioned at the rear of the bowl, open the apron enough to allow material to enter the bowl (normally 4 to 8 inches above the leading edge of the bowl), and then lower the bowl to cut a depth of 1 to 1 1/2 inches. The gear that the transmission is engaged in depends on the nature of the material being cut. For light, loose material, a relatively high gear can be used. For heavy compacted material, a low gear is used; however, to obtain a full load, you should use a lower gear, even in loose material. As the scraper proceeds through the cut, the material is loosened by the scraper cutting edges and forced into the bowl by the forward motion of the scraper (fig. 10-39).

NOTE: Avoid spinning the scraper tires during cut operations. Spinning the tires is nonproductive and causes expensive premature wear of the tires, differential, and transmission.

The material entering the bowl boils back against the ejector and forward against the apron (fig. 10-40). When the bowl is filled to capacity (commonly know as heaped), close the apron, and at the same time, raise the bowl 1 or 2 inches above the ground (fig. 10-41). On scrapers equipped with diverter valves in the apron hoist system, the bowl automatically starts raising, while the apron control lever is held in the lower position. After the scraper is fully loaded and the bowl is raised, continue to travel out of the cut with the scraper bowl at a height that spreads out the material that piles in front of the cutting edges.

The push cat supplies extra power to the scraper during loading operations. When a push cat is used, it should be positioned about 45 degrees off the lane to be cut. The scraper should start loading before the push cat makes a smooth contact with the rear push block (fig. 10-42).

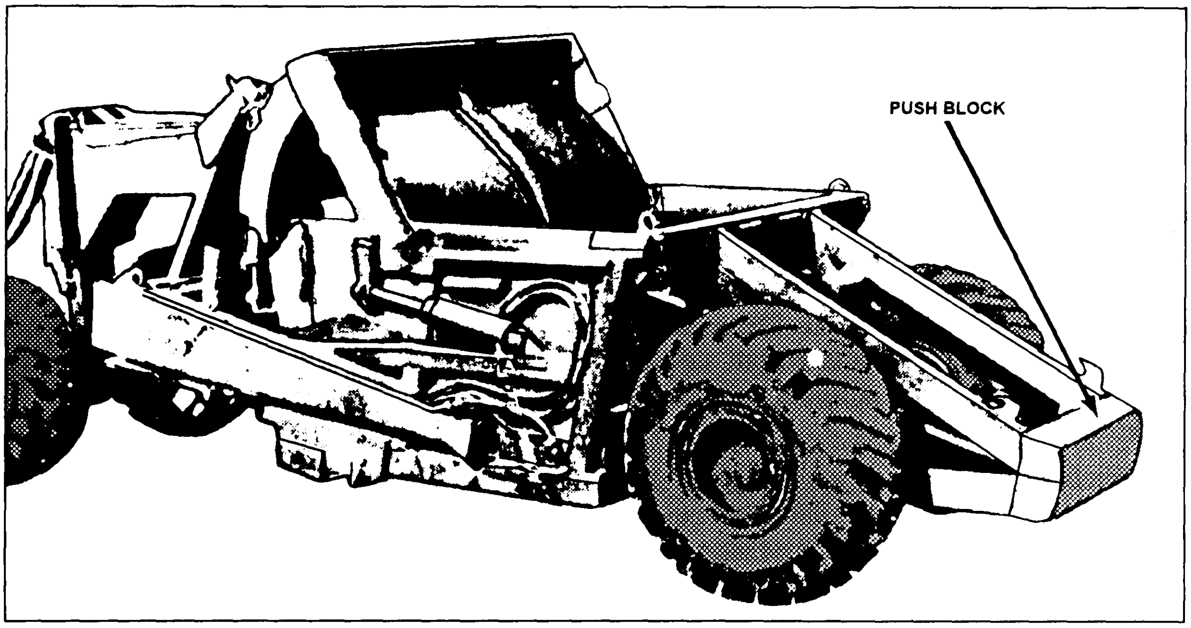


Figure 10-42.-Push block.

NOTE: The push cat operator should be extremely cautious in NOT hitting the rear scraper tires with the dozer blade.

The push cat operator must ensure that the reinforced section of the dozer blade is centered on the scraper rear push block. Additionally, the push cat operator must be alert to turns made by the scraper that might cause the push cat to apply unequal pushing force. This could result in the dozer blade contacting the scraper rear tires or causing the scraper to jackknife. The push cat should continue pushing after the scraper has a full load to give the scraper a boost in leaving the cut.

Hauling

After the scraper is fully loaded and has reached the haul road, the operator should raise the bowl to travel height and proceed to the fill or dump area in the highest gear range practicable. The bowl travel height should be no higher than needed to clear any obstacles on the haul road. A low bowl height allows better control of the scraper by keeping the center of gravity low and preventing the loss of time needed to lower the bowl, as the scraper approaches the fill area. The best bowl height is the height at which the bowl must be in when the load is spread.

When hauling down steep grades, lower the bowl until the blade drags to slow the scraper down. When traveling over a slippery haul road, keep the cutting edges as close to the road as possible to allow for a fast emergency stop by dropping the bowl.

When traveling over haul roads, avoid holes and large obstacles that may damage the scraper tires. When making sharp turns, allow enough clearance for the length and width of the scraper to keep the scraper wheels on the road.

Spreading or Unloading

When approaching the fill area, lower or raise the scraper bowl to the depth of fill desired. The speed of the scraper must also be adjusted for this depth, such as a high speed for a thin spread or a slower speed for a deep spread.

To start spreading, raise the apron by engaging the apron control lever to allow the material to fall out of the bowl. The size of the apron opening depends mainly upon the depth of the spread and type of material being spread; for example, a thin layer of free-flowing sand needs a fairly small apron opening and a high travel speed, while a thin spread of wet clay will need a larger opening and a slower travel speed.

After the apron opening has been adjusted and the dirt flowing through the opening lessens, engage the ejector lever to finish unloading the scraper bowl. When the scraper is empty, engage the ejector lever to return the ejector to the rear of the bowl and lower the apron.

Unloading techniques are as follows:

- Keep the scraper moving while unloading. Stopping when unloading on soft fill costs production time by needless shifting and the possible miring down of the scraper.

- Always make an even spread, so the next trip will not be rough.

- If possible, when traveling out of a fill, pass back over the area you have just filled to compact it with the large scraper tires.

Returning to the Cut

After the scraper is unloaded and has reached the haul road, return to the cut as soon as possible. When returning to the cut, carry the scraper bowl high enough to avoid any haul road obstacles, yet low enough for safe handling of the scraper. Carrying the bowl low allows for quick lowering of the bowl to stop the scraper in the event of an emergency. Allow plenty of room for the rear wheel of the scraper to avoid obstacles when making tight turns, and maintain a safe speed for the condition of the haul road.

WORKING DIFFICULT MATERIALS

Special operating techniques are required when performing scraper operations in difficult materials, such as wet or sticky material, loose sand or gravel, and large objects.

Wet and Sticky Materials

When unloading wet and sticky material, do not try to spread the material too thin. Always keep the bowl high enough to allow the material to flow back under the scraper. Open the apron wide enough to allow an easy flow out of the bowl, Bring the ejector forward with short, snappy movements of the ejector control lever to shake the material loose from it. Allow a little time between each ejector movement to avoid compacting the material between the apron and ejector. In some cases, shifting the ejector between forward and reverse gives the material that has been brought forward a chance to fall out the apron opening.

NOTE: When the material is spread too thin or the bowl is too low, the material will pack against the scraper cutting edge inside the bowl and will not eject.

Loose Sand and Gravel

Sand is a free-flowing material that tends to float ahead of the scraper cutting edges when being loaded. To obtain a heap scraper load when loading and to avoid being bogged down by the sand, use the technique called ***pump loading.*** To pump load, enter the cut with the apron open about 3 feet and the scraper cutting edges lowered into the sand. Continue through the cut until the engine(s) starts to lug down. Then lower the apron into the sand that has piled up in front of the scraper cutting edges, and raise the bowl 2 or 3 inches at a time. Do not completely close the apron or drop the bowl so deep that the engine stalls. This **pump loading** technique will ordinarily allow the scraper to get a full load.

When spreading sand, always spread it as thin as possible, and keep the scraper moving in the fill. A thin spread allows better compaction and makes it easier to travel over the fall.

To obtain a full load when loading gravel, you may have to **pump load** as performed with sand. The apron may be hard to close due to stones getting caught between the apron and cutting edges. A technique used to avoid the stones is to backup a few inches with the blade still in the ground while closing the apron. This should force the stones out and allow the apron to close all the way.

Large Objects

Scrapers are not designed to dig or transport large objects; however, they may be used for this purpose when more suitable equipment is not available.

Approach the object with the apron and scraper bowl fully raised. When the object is too large to clear underneath the tractor, bring the tractor past the object until the drive wheels are a few inches beyond it. Pivot the tractor sharply towards the object to allow the tractor to bypass the object, and bring the cutting edge into position for loading (fig. 10-43).

When the tractor reaches its sharpest angle of the turn, bring the scraper cutting edges within a few inches of the object. Lower the bowl, apply down pressure, and move forward. When the cutting edge hooks underneath the object, lift the bowl while inching forward. When the object slips off the cutting edge, back up and try again. You may have to approach the object from a different direction to get a grip to load the object.

To shove the object around, keep the ejector in the full forward position. When the object is to be picked up and carried, place the ejector in the normal fullback position. To close the apron completely after the object

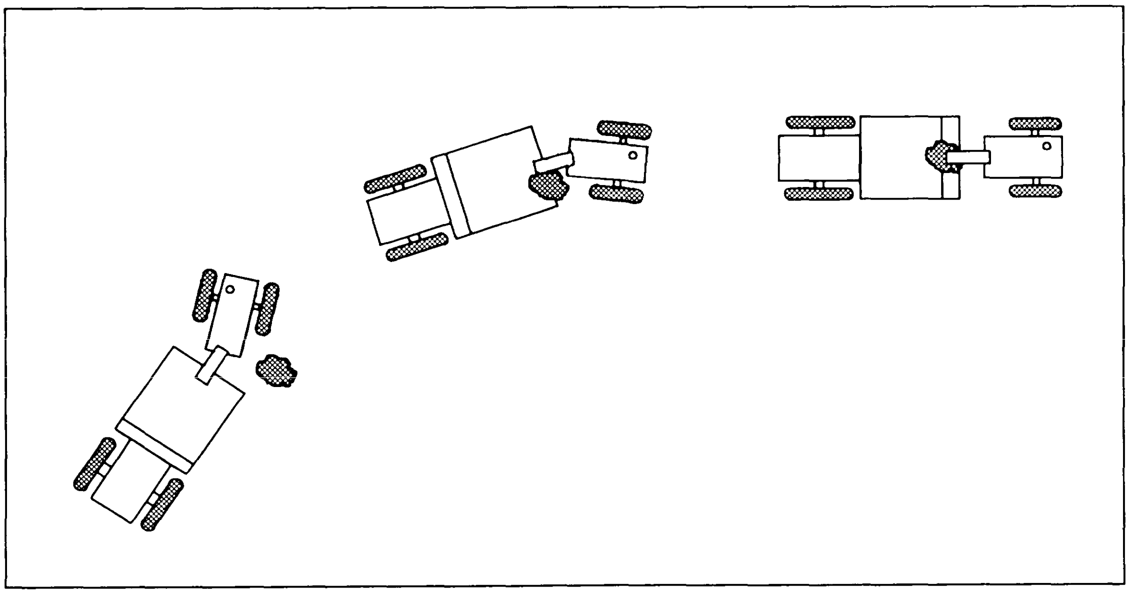


Figure 10-43.-Scraper maneuver to load large object.

has been loaded, scrape up a little dirt that will push the object back further into the bowl.

To unload the object, shift the ejector from forward to reverse several times to move the object around so it will fall out. After the object has been unloaded, turn the tractor sharply so the scraper clears the unloaded object.

NOTE: Use extreme care when handling large objects. Oversize objects, such as large rocks, can cause damage by denting, bending, or straining parts. Damage may also be done by accidental collision with large rocks during ordinary digging.

PRODUCTION TECHNIQUES

Scraper production techniques are used to achieve the most amount of work with the scrapers assigned. These techniques are as follows.

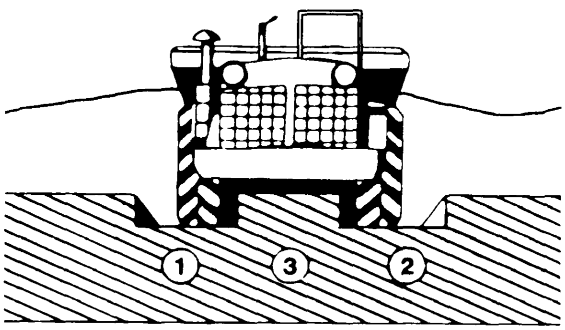


Figure 10-44.-Straddle loading.

Downhill Loading

Downhill loading uses the force of gravity on the scraper to get larger loads in less time. The added force of gravity is 20 pounds per gross ton of weight per 1 percent of downhill grade. The downhill pull adds more material per load, and the added material weight increases the total gravitational pull.

Straddle Loading

Straddle loading gains time on every third trip because the center strip loads with less resistance than a full cut. After the first scraper has made a cut, the second scraper should make a parallel cut and leave a 4- to 5-foot-wide island between the two cuts, as shown in figure 10-44. The third scraper can straddle this island of material to achieve a fast, less resistance load.

Back-track Loading

Back-track loading is the method where the cut is fairly short and loading in both directions is impractical. As shown in figure 10-45, too much time is spent back tracking and maneuvering the push cat for the next load. When the cut is wide enough, other methods should be tried.

Shuttle Loading

Shuttle loading is used for short cuts where it is possible to load in both directions, as shown in figure 10-46. The push cat pushes one scraper in one direction, then turns and push loads a second scraper in the opposite direction.

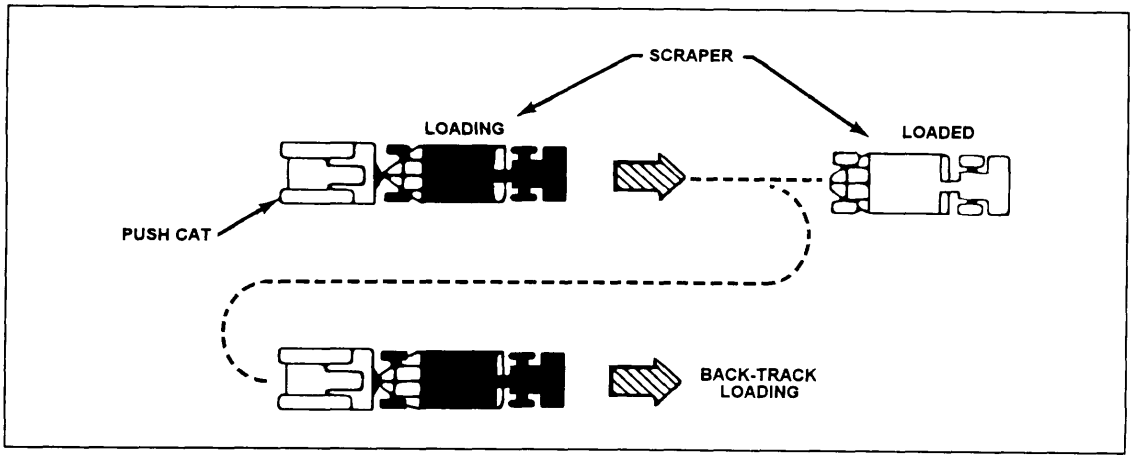


Figure 10-45.-Back-track loading.

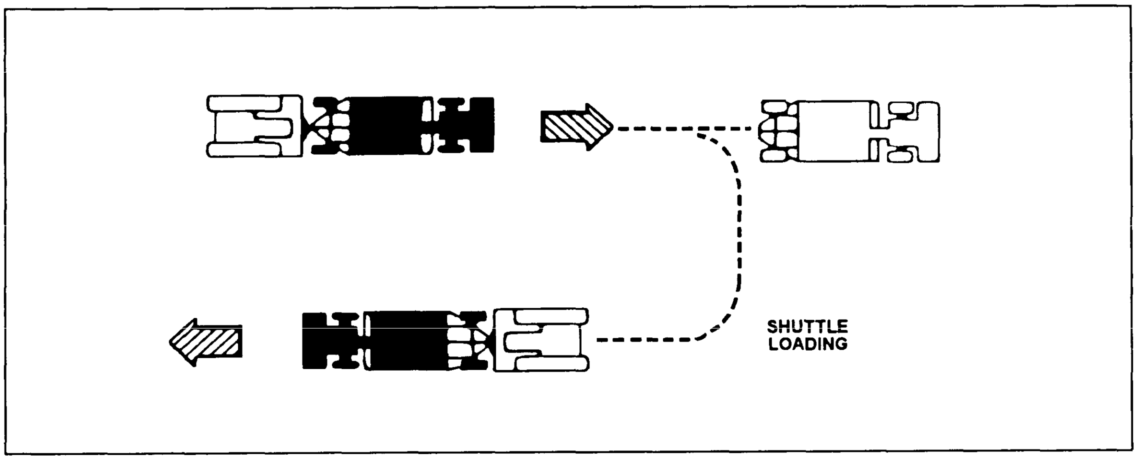


Figure 10-46.-Shuttle loading.

Chain Loading

Chain loading is used where the cut is fairly long, making it possible for the push cat to pickup two or more scraper loads without back tracking, as shown in figure 10-47. The push cat push loads one scraper, then moves in behind another scraper, moving parallel to the first in an adjacent lane.

Optimum Loading

Optimum loading is an operation when loading time and maximum output are critical. Push-loaded scrapers should be loaded within 1 minute and within a distance of 100 feet. More time and distance may be used to obtain more material when the haul is long enough, and the added material is great enough to offset hauling fewer loads because of longer loading time.

When scrapers are backed up at the cut waiting for push cat assistance, let the scrapers cut without attaining a heaped load. When push cats are waiting for scrapers, increase loading time to achieve maximum loading. Make sure push cats use wait time to dress the cut. In some cases, it will increase production to use a dozer full time to dress the cut. At the end of a workday, take the time to shape the cut for good drainage.

NOTE: Maintaining adequate drainage throughout a cut and fill operation reduces compulsory downtime caused by bad weather.

The rule of thumb used for computing the number of push cats required for a scraper operation is to divide the scraper cycle time by the push cat cycle time. When computing cycle time for a scraper, take the total time of loading, hauling, unloading, and return; for instance,

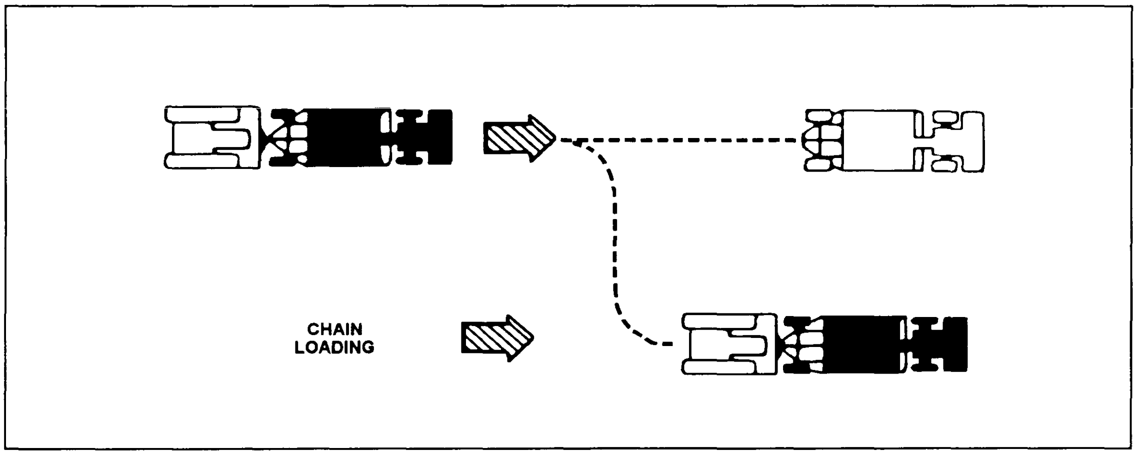


Figure 10-47.-Chain loading.

a 5-minute scraper cycle time divided by a 1-minute push cat cycle time calls for five scrapers per push cat.

Turns

When making turns, turn within the shortest radius possible and at the highest safe speed When making turns to perform cut and spread operations, use the sequence shown in figure 10-48.

Haul Roads

Haul roads should be level and laid out so time is not wasted in maneuvering the scraper. A haul road that has drastic changes in elevation reduces production. Haul roads should be kept in good condition and moist. Roads kept moist, not wet, packs into a hard smooth surface that permits higher travel speeds. The moisture also controls dust that gets into all parts of the scraper, resulting in increased lubrication problems and premature wear. Additionally, controlling the dust allows better visibility.

If the haul road is a dirt road and needs grading, while returning to the cut, maintain the road occasionally with the scraper blade. This is performed by opening the apron approximately 12 inches above the cutting edges and the ejector positioned forward to within 6 inches of the cutting edge. The bowl is lowered until the cutting edges scrape about 1 to 2 inches of the road surface. By watching the road, the operator can vary the cutting action to trim small rises and carry the material to fill depressions, as the scraper travels the haul road These grading operations can be performed in second or third gear, depending upon road conditions. Grading should only be done when the road surface has ruts and rough or soft spots.

NOTE: Scrapers on the haul road should only travel in the highest gear that is safe for the road

Scraper Spacing Efficiently

Scrapers should be teamed by their speed whenever possible. The fastest scrapers should be assigned to one section of a job, while the slower ones are on another. They should use different haul roads if possible.

NOTE: No scraper can travel faster than the scraper ahead of it. Passing only increases the chances of accidents.

Scraper operators can help in traffic control by speeding up to close along gap and slowing down when too close. Efficient spacing supports the optimum use of the push cat. When unloading and lagging far behind the next scraper, spread the load at the beginning of a

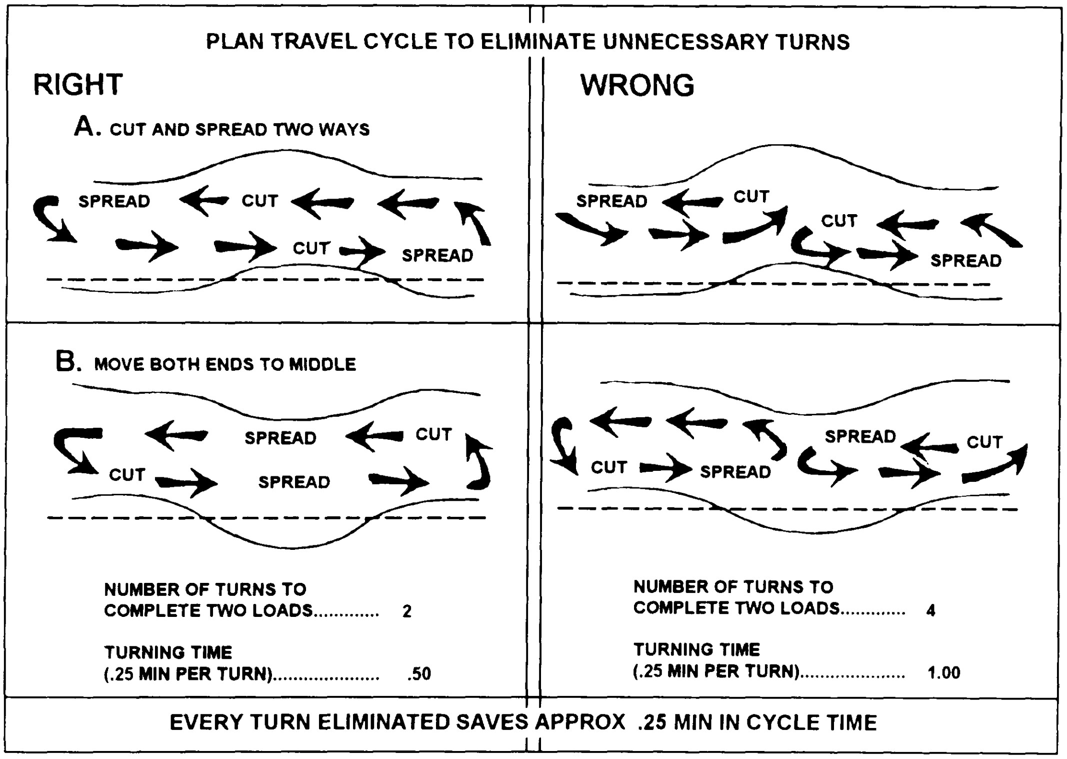

PLAN TRAVEL CYCLE TO ELIMINATE UNNECESSARY TURNS
RIGHT
A. CUT AND SPREAD TWO WAYS
SPREAD
CUT
CUT
SPREAD
B. MOVE BOTH ENDS TO MIDDLE
SPREAD
CUT
CUT
SPREAD
NUMBER OF TURNS TO COMPLETE TWO LOADS............ 2
TURNING TIME (.25 MIN PER TURN).................... .50
WRONG
SPREAD
CUT
CUT
SPREAD
SPREAD
CUT
CUT
SPREAD
NUMBER OF TURNS TO COMPLETE TWO LOADS............ 4
TURNING TIME (.25 MIN PER TURN).................... 1.00
EVERY TURN ELIMINATED SAVES APPROX .25 MIN IN CYCLE TIME

Figure 10-48.-Cut and spread sequence.

fill. When traveling too close to the next scraper, spread the load at the far end of the fall.

NOTE: Keep the scraper bowl as close to the ground as possible to lower its center of gravity and to keep it upright.

Spreading

Techniques for scraper spreading operations are as follows:

- Spread the first load at the start of the fill.
- Travel with subsequent loads over the previous fill, provided lifts are small.
- Make each following spread start at the end of the previous layer.
- Finish spreading in one full length before starting a new lane, so rollers can begin compaction.
- Route the scrapers to compact the fill. Overlapping the scraper tire tracks aids in the compaction of the entire area and reduces the compaction time necessary with a roller.
- Spread in the highest gear permitted by the condition of the fill area terrain.

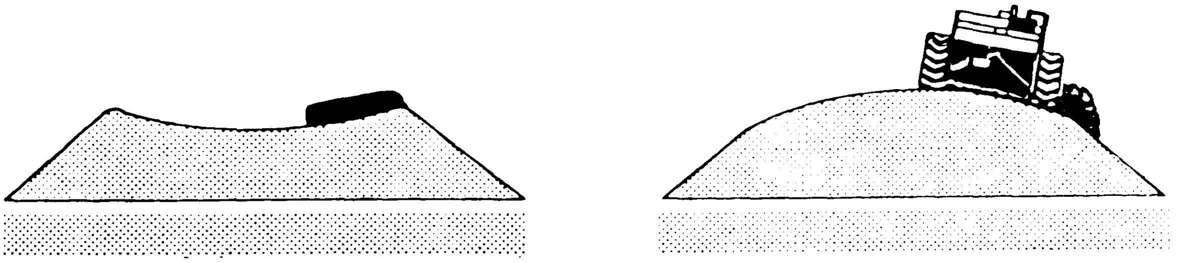
NOTE: Slowly discharging loads at low speed slows down production and cycle time.

- Do not waste time on the fill. As soon as the load is spread, get the scraper back on the haul road and return to the cut. Plan your exit from the fill to avoid soft ground and detours around trees and other obstacles.
- As shown in figure 10-49, make the fill high on the outside edge. This prevents the scraper from sliding over the outside edge and helps in maintaining accurate slopes to desired heights. When the fill is not made in this manner, the scraper tends to work away from the edge of the fill, making it hard to maintain the correct slope. In inclement weather, build the low center up for drainage.

SCRAPER SAFETY

Safety precautions that apply to scrapers are as follows:

- Never operate a scraper at speeds that are unsafe.
- Always wear seat belts. Uneven terrain can cause a violent tilt of the scraper, causing possible personal injury by throwing you off or against the steering wheel if NOT secured in the operator's seat.



RIGHT WAY

TO MAINTAIN FILL SLOPE

1. MAKE FILL HIGH ON THE OUTSIDE
2. THIS PREVENTS SCRAPER FROM SLIDING OVER SLOPE
3. ACCURATE SLOPES CAN THUS BE MAINTAINED TO DESIRED HEIGHTS ELIMINATING NECESSITY FOR HANDWORK
4. IF WET CONDITIONS PREVAIL, ARRANGE FOR DRAINAGE TO PREVENT WATER POOLING IN CENTER OF FILL

WRONG WAY

RESULTS OF INCORRECT METHOD

1. SCRAPER WILL SLIDE OVER SIDE OF WALL
2. DAMAGE TO SLOPE WILL BE CAUSED
3. IMPOSSIBLE TO MAINTAIN ACCURATE DEGREE OF SLOPE HAVING TENDENCY TO WORK AWAY FROM EDGE OF FILL

Figure 10-49.-Proper placement of fill material.

- Block up the scraper bowl and apron before performing any work on the cutting edges of the scraper.

- Keep the operator's cab clear of debris, grease, oil, and mud which can cause the operator to slip or fall.

- Never kick the scraper out of gear when going downhill. The increased speed will make control of the scraper very difficult. Keep the scraper in gear at all times and use the cutting edge to control the speed When the brakes fail to hold the load, lower and drag the scraper bowl.

- When securing the scraper, ensure the apron is closed and the bowl on the ground.

- Do NOT spread when turning.

- When working on slopes, always turn uphill.

- Do NOT drop the bowl suddenly; ease the cutting edge onto the ground.

- Load and spread when going downgrade, whenever possible.

- When constructing a fill, keep the outside edge high and the center low to prevent the scraper from sliding over the edge.

- When the scraper begins to fall off the fill, steer downhill, drop the bowl, and rapidly accelerate to maximum rpm. Do NOT attempt to turn the scraper back up the slope. Do NOT stop the forward motion of the scraper when there is any danger of the unit tipping over.

- Wear any required personal protective equipment, such as hard hats and steel toe safety shoes.

CHAPTER 11

DOZERS AND ROLLERS

The dozer, technically known as a **crawler tractor,** is used as follows: as a prime mover for pushing or pulling loads, as a power unit for winch operations, or as a dozer for earthwork operations and demolition work. Rollers are compaction equipment used to achieve mechanical compaction of earthwork materials required by project specifications.

A variety of makes and models of dozers and rollers are used by the Navy and the Naval Construction Force (NCF). Each operator is responsible for reading the operator's manual to obtain detailed information about each make and model. This chapter covers the general characteristics and basic principles of dozer and roller operations.

DOZERS

The dozer, commonly called a **bulldozer,** is a crawler tractor on which a dozer blade has been mounted (fig. 11- 1). Dozers are usually rated by size and power. The pull developed at the drawbar is expressed in pounds or as **drawbar horsepower.** The drawbar pull is greatest in the lowest transmission gear range. Although the specifications for dozers may vary among different manufacturers, the maximum speeds are seldom in excess of 8 mph.

The dozer is equipped with a diesel engine and is supported on the ground by a track assembly. The track assembly provides all-type-terrain versatility due to the low ground bearing pressure at the track. This lower ground bearing pressure, varying from 6 to 9 pounds per square inch, has a distinct **flotation** advantage over rubber-tired equipment ground bearing pressure that varies from 25 to 35 pounds per square inch. Dozers are capable of operating efficient y in muck or water as deep as the height of the track for short periods of time. When the dozer is properly waterproofed, it can operate in fairly deep water.

CAUTION

When working in water that is deep enough to reach the radiator, be sure to disconnect the fan belt. If the fan blades hit the water while under power, the y could bend or break off, possibly causing damage to the radiator. Additionally, exercise extreme caution to ensure the engine does not overheat when the fan or water pump belts are disconnected.

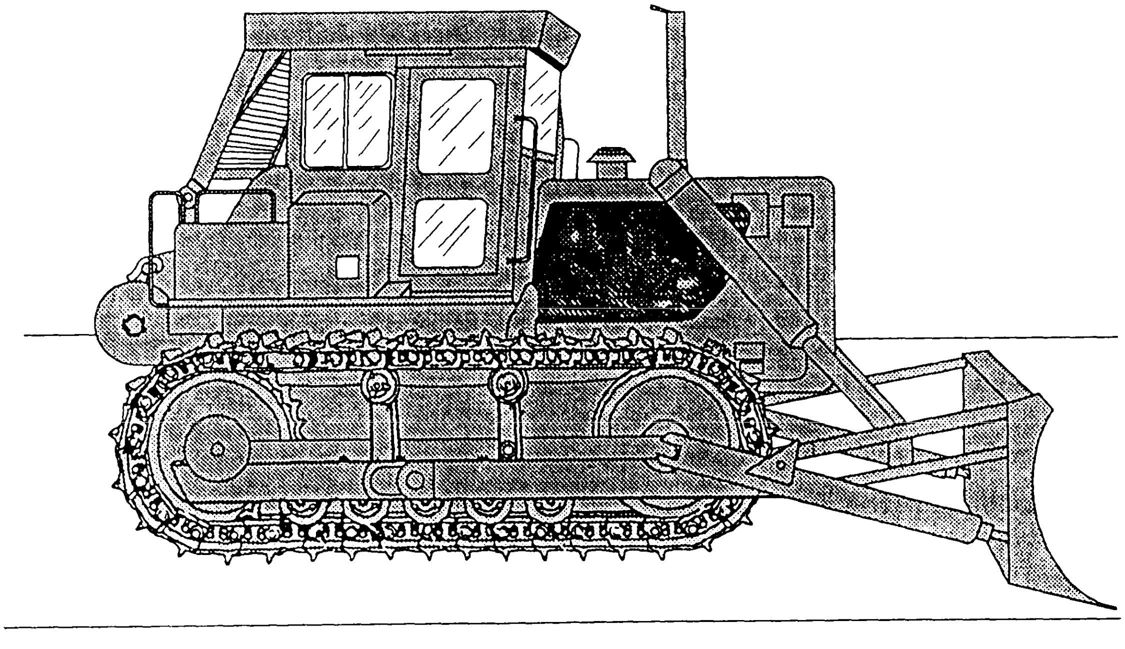


Figure 11-1.—Dozer.

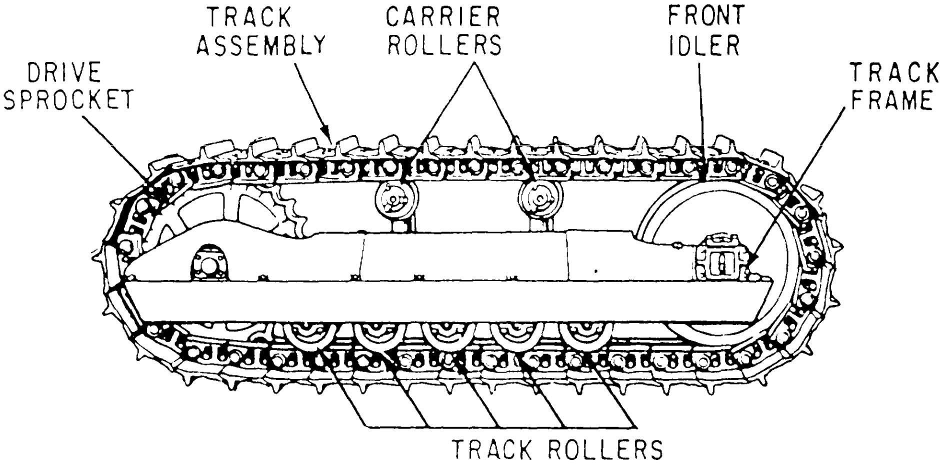


Figure 1-2.-Side view of crawler tractor chassis.

Dozers can move from jobsite to jobsite under their own power at slow speeds; however, this is a poor practice and tends to shorten the operational life of the dozer. For this reason, dozers should be transported by tractor-trailer from jobsite to jobsite.

TRACKS AND TRACK FRAME

The undercarriage of the crawler-mounted dozer contains two major components: **track assembly and track frame.** The undercarriage (fig. 11-2) shows positive traction, allowing efficient operations.

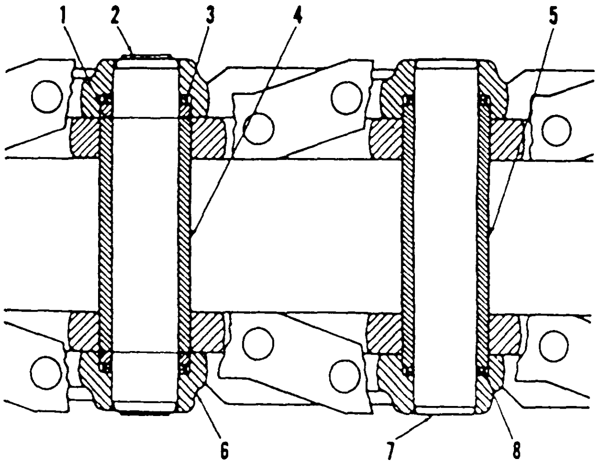
Track Assembly

The track assembly consists of a continuous chain surrounding the track frame and drive sprocket. The links of the chain provide a flat surface for the track rollers to pass over, as they support the equipment. Track shoes are bolted to the outside of the chain links and distribute the weight of the equipment over a large surface. The distribution of the weight is the ground bearing pressure.

TRACK CHAIN.— Figure 11-3 shows a cutaway view of a section of track chain, showing the internal arrangement of the pins and bushings. As the dozer operates, the drive sprocket teeth contact the track pin bushings and propel the dozer along the track assembly.

The pins and bushings wear much faster than other parts of the track because of their constant pivoting, as the track rotates around the track frame. The pivoting results in internal wear of both pins and bushings. As the pins and bushings wear, the track lengthens. When it does, the track should be adjusted to remove any slack.

Extensive wear on the outside of bushings is a good indication of inner wear. Manufacturers have set specifications for the maximum wear allowed before a track has to be rebuilt. To determine if a track should be removed for rebuilding or replacement, measure the outside of the bushings and track pitch (length of the track). Measure the outside of the bushing at the location at which it shows the most wear using a caliper and ruler, as shown in figure 11-4. Compare this measurement with the manufacturers' specifications. Measure the



1. Spacer
2. Master Pin
3. Coned-Disk Seal Washers
4. Master Bushing
5. Track Bushing
6. Link
7. Track Pin
8. Coned-Disk Seal Washer

Figure 11-3.—Track chain.

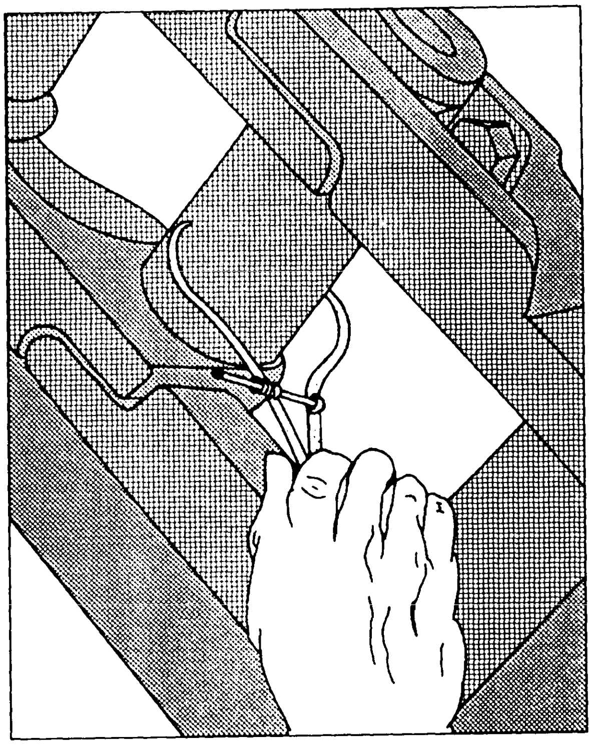


Figure 11-4.—Bushing wear measurement.

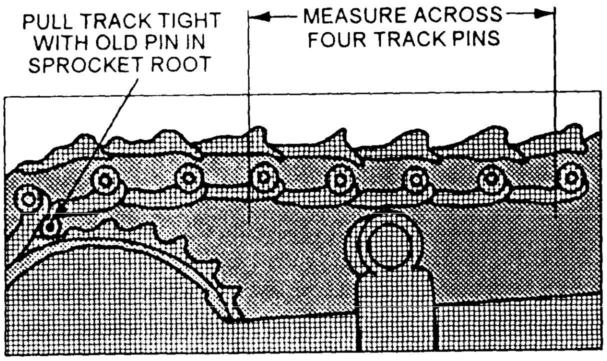

PULL TRACK TIGHT WITH OLD PIN IN SPROCKET ROOT
MEASURE ACROSS FOUR TRACK PINS

Figure 11-5.—Track pitch measurement.

track pitch with a ruler or tape measure after tightening the track to remove any slack, as shown in figure 11-5.

TRACK SHOES.— The most common track shoe is the grouser shoe, as shown in figure 11-6. This shoe is standard on crawler-mounted dozers. The extreme service track shoe shown in figure 11-7 is equipped on crawler-mounted dozers that operate primarily in rocky locations, such as rock quarries and coral beaches. Notice the grouser, or raised portion of the shoe, is heavier than the one on the standard grouser shoe.

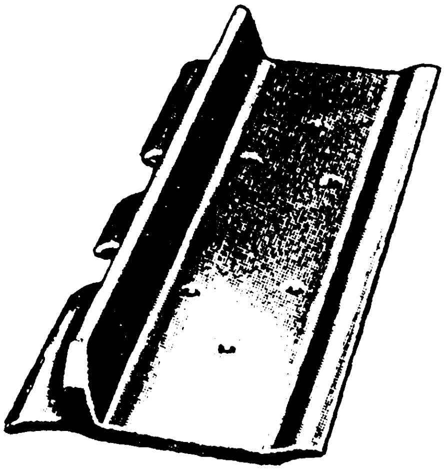


Figure 11-6.-Standard grouser shoe.

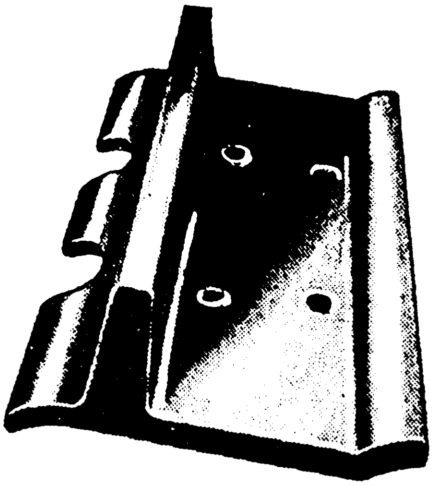


Figure 11-7.—Extreme service track shoe.

NOTE: The grouser absorbs most of the wear and its condition can indicate when a track needs replacement or overhaul.

Track Frame

The track frame serves as a framework and support for the track assembly, rollers, front idler, recoil spring, and adjusting mechanism.

TRACK FRAME ROLLERS.— Two types of track frame rollers are used on tracked equipment: those located on the lower portion of the track frame, which support the weight of the dozer, and those mounted above the track frame, which support the track, as it passes over the track frame assembly.

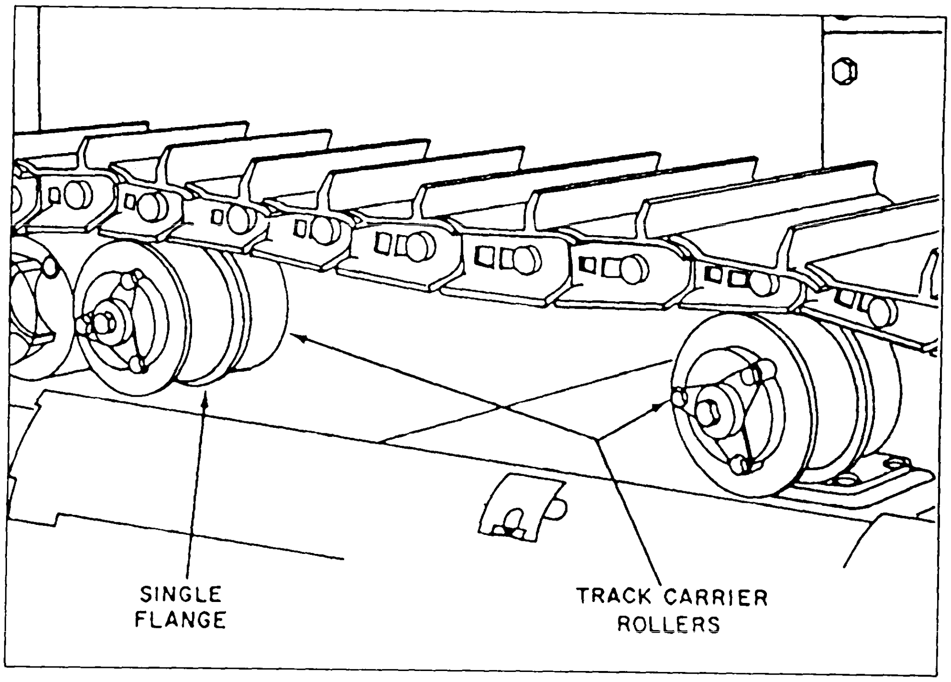


Figure 11-8.-Carrier rollers.

The carrier rollers are mounted on brackets that extend above the track frame (fig. 11-8). Two of these rollers are on each side of the dozer. The single flange on the rollers extends upward between the links of the track chain and keeps the chain in alignment between the drive sprocket and the front idler.

The track rollers support the weight of the dozer and ensure the track chain is in alignment with the truck frame, as it passes under the rollers (fig. 11-9). Track rollers, both single and double flanged, are installed alternately. In the normal arrangement, a double-flanged roller is positioned directly in front of the rear drive sprocket, followed by a single-flanged roller. The rollers alternate forward to the front idler.

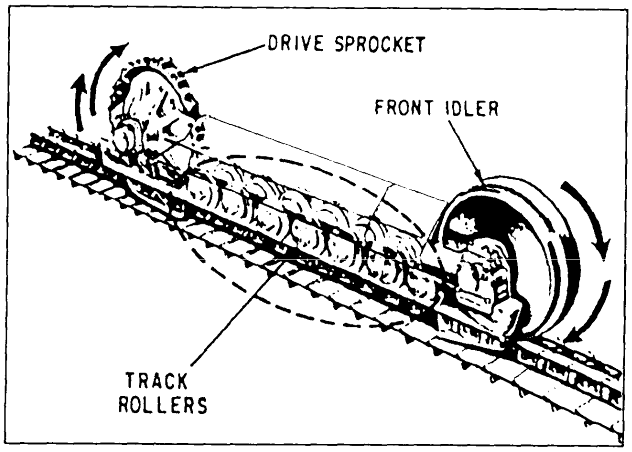


Figure 11-9.—Track rollers in position in track frame.

FRONT IDLER.— The front idler, as shown in figure 11-9, serves as a guiding support for the track chain. The idler is spring-loaded and mounted on slides, or guides, that allow it to move back and forth inside the track frame, as the dozer passes over uneven ground. The spring-loading effect causes the idler to maintain the desired tension regardless of operating conditions.

RECOIL SPRING.— The recoil spring is a large coil spring placed in the track frame in a way that enables the spring to absorb shock from the front idler. The spring is compressed before installation and held in place by stops or spacers. The track adjusting mechanism, by pressing against the spring stop, maintains the desired tension on the track assembly by holding the idler and yoke in the forward position. The operation of the coil spring depends on the amount of tension on the truck.

TRACK ADJUSTING MECHANISM.— The adjusting mechanism must be extended enough to remove slack between the front idler and spring. The adjustment is made either manually (fig. 11-10) or hydraulically (fig. 11-11). Older model dozers have mnaually adjustments; whereas, newer dozers are

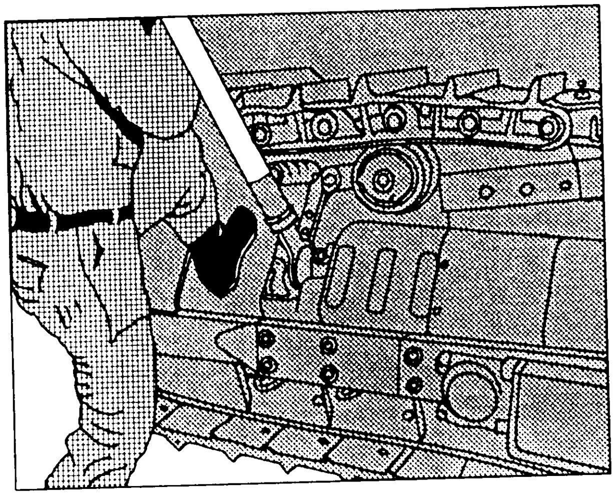


Figure 11-10.-Manual track adjustment.

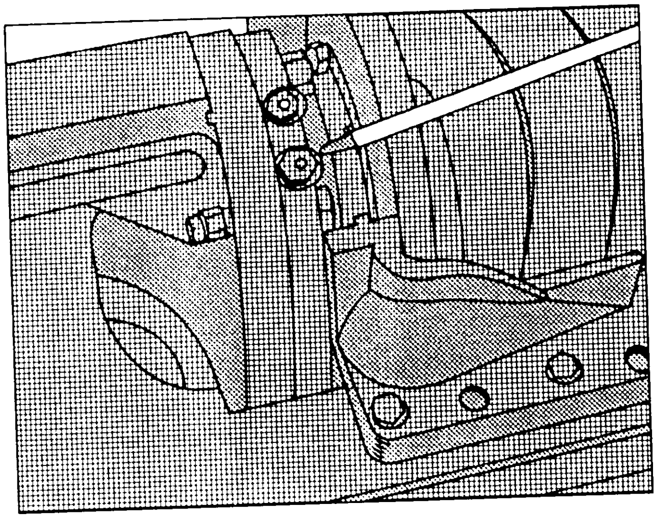


Figure 11-11.-Hydraulic track adjuster.

adjusted hydraulically with a grease gun. Grease is pumped into the yoke cylinder and extends it until enough tension is placed on the recoil spring to remove the slack from the track. Tension is relieved by loosening the vent screw located next to the adjustment fitting.

NOTE: Do NOT lubricate this fitting when performing daily operator's maintenance. The track adjuster fitting should only be greased when the tracks require adjustment.

Track Adjustment.— To determine proper track tension, position the dozer on a hard surface. Then place a straightedge over the front carrier roller and idler with all slack removed from the rest of the track. The tension is correct when the measured distance is as shown in figure 11-12.

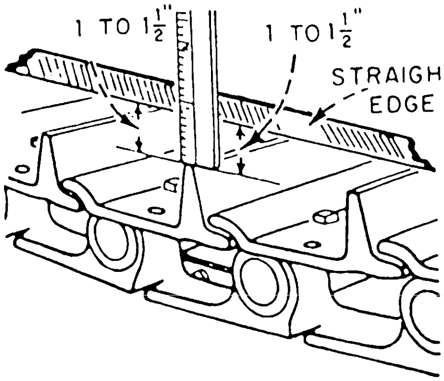


Figure 11-12.—Checking track adjustment.

Track tension should be suitable for the type of area you arc working in, such as tighter for rock and looser for sand and snow. However, if the tracks are adjusted too tightly, there will be too much friction between the pins and bushings when the track links swivel, as they travel around the sprocket and front idler. This friction causes the pins, bushings, links, sprocket, and idler to wear rapidly. Friction in a tight track also robs the tractor of needed horsepower.

Tracks that are too loose fail to stay aligned and tend to come off when the tractor is turned. As a result, the idler flanges, roller flanges, and the sides of the sprocket teeth wear down. A loose track will whip at high speeds, damaging the carrier rollers and their supports. If loose enough, the drive sprockets will jump teeth (slide over the track bushings) when the tractor moves in reverse. Should this happen, the sprocket and bushings will wear rapidly.

NOTE: Checking and performing track adjustments arc the opcrator's responsibility.

Lubrication.— The track pins and bushings are hardened and require no lubrication. Many roller idlers arc equipped with lifetime seals that are filled during assembly and require no lubrication. However, track rollers, carrier rollers, and idlers equiped with grease fittings must be lubricated on a schedule based on the manufacturer's specifications.

NOTE: Fittings should be cleaned before lubricating to prevent forcing dirt and grime into the bearings.

ATTACHMENTS

The most common type of dozer attachment is the dozer blade, a heavy, rectangular steel blade, that is on

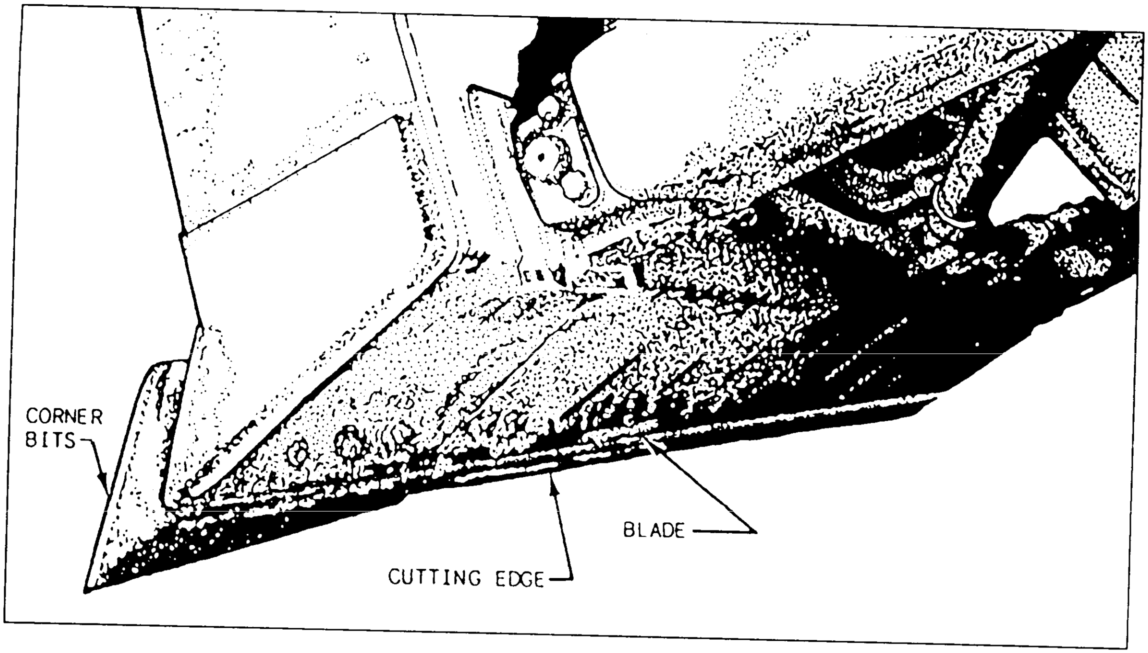


Figure 11-13.-Cuttting edge and corner bit.

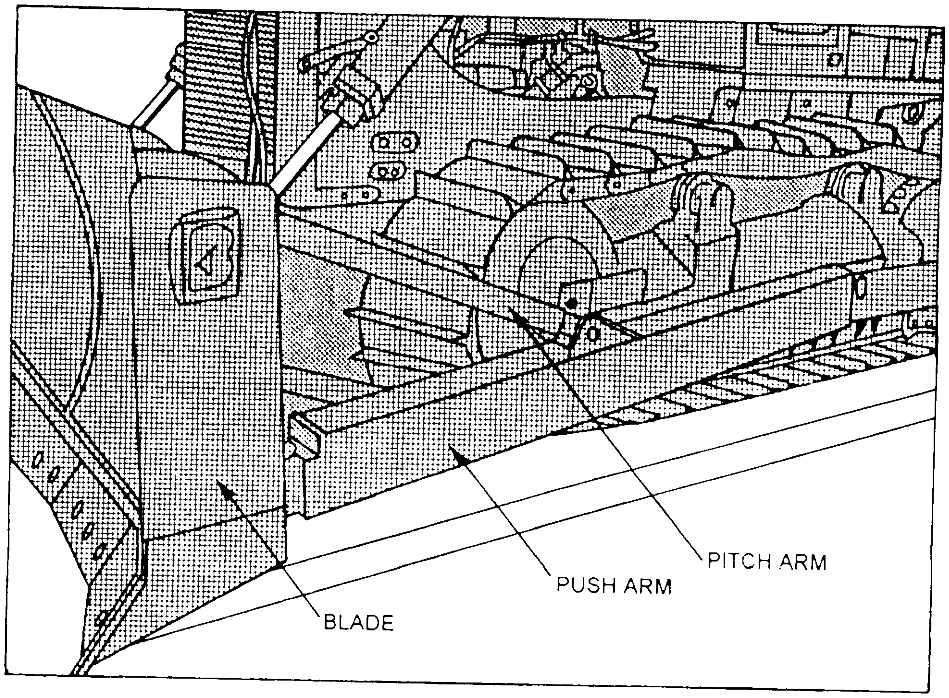


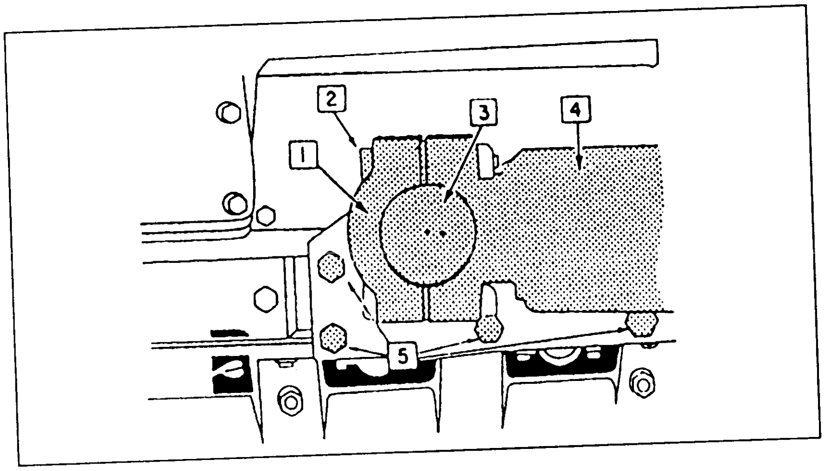
Figure 11-14.—Dozer blade, push and pitch arms.

the front of the crawler tractor. It is used for drifting (pushing straight ahead) or side casting (pushing to one side) materials. Other attachments include rippers and winches.

Dozer Blades

A dozer blade cutting edge and corner bits are boltcd to the bottom of the blade (fig. 11-13). Remember, checking the cutting edges for wear is the operator's responsibility. The blade is connected to two push arms and two pitch arms, as shown in figure 11-14.

Most push arms are attached to the bottom of the blade and to the outside of the track frame at the trunnion (fig. 11-15). On dozers equipped with an angle blade, the-push arms are a "C" frame confjguration. The "C" frame is attached to the trunnions and wraps around the front of the dozer. The blade is attached to the "C" frame with a steel pin.



1. CAP, trunnion
2. BOLT, cap
3. TRUNNION
4. "C" FRAME or PUSH ARM
5. CAP SCREW, trunnion mounting

Figure 11-15.—Push arm and trunnion.

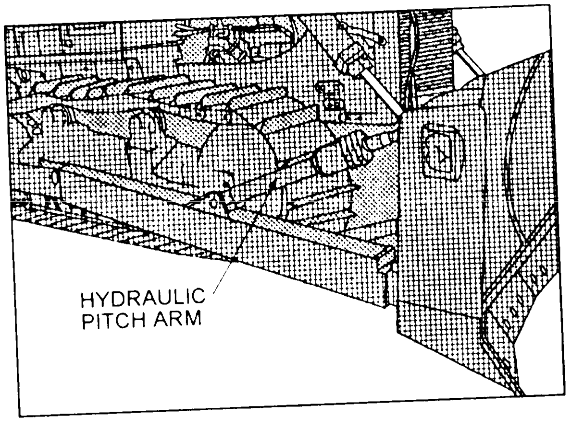


Figure 11-16.—Hydraulic pitch arm.

Pitch arms arc diagonal members between the push arm and the top of the blade. They brace the blade against loads above the push arms and provide a means of regulating the blade pitch and tilt. The pitch arms may be threaded or have a hydraulic cylinder, as shown in figure 11-16. To pitch the blade forward, lengthen the arms. The forward blade pitch is for dozing extremely hard materials. Pitch the blade back by shortening the pitch arms. The back blade pitched is good for leveling, spreading, or cleaning of loose material without the blade digging in. Tilting is done by shortening one arm and lengthening the other.

STRAIGHT BLADE.— The straight blade (fig. 11- 17) is ideal for general dozing when materials are to

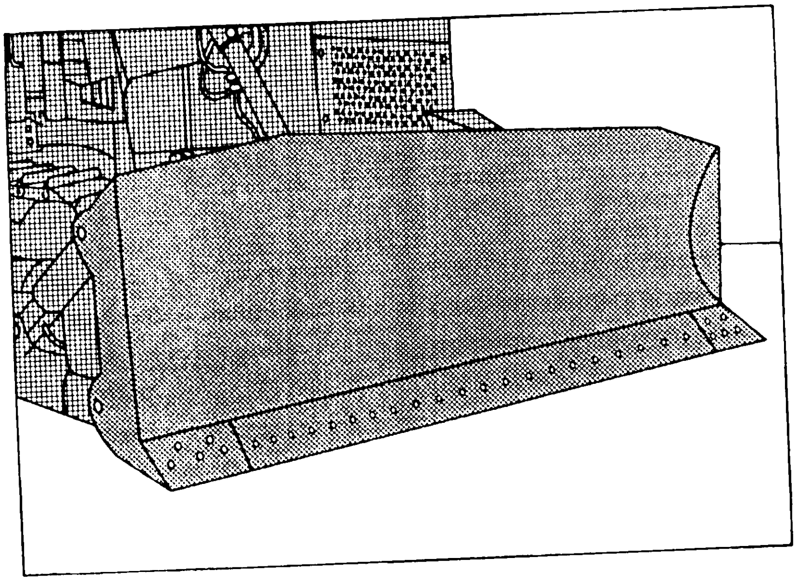


Figure 11-17.-Straight blade.

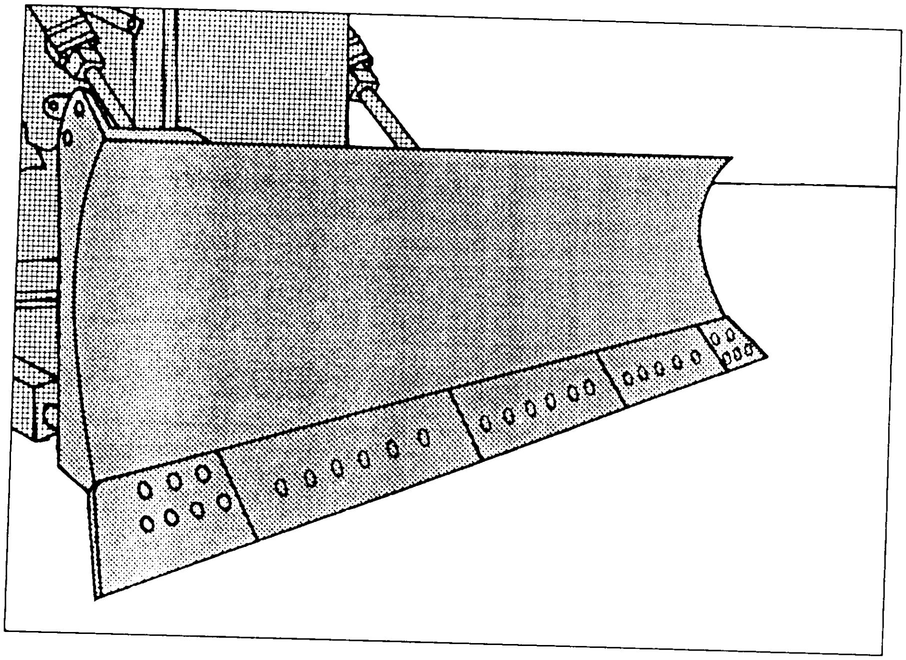


Figure 11-18.—Angle blade.

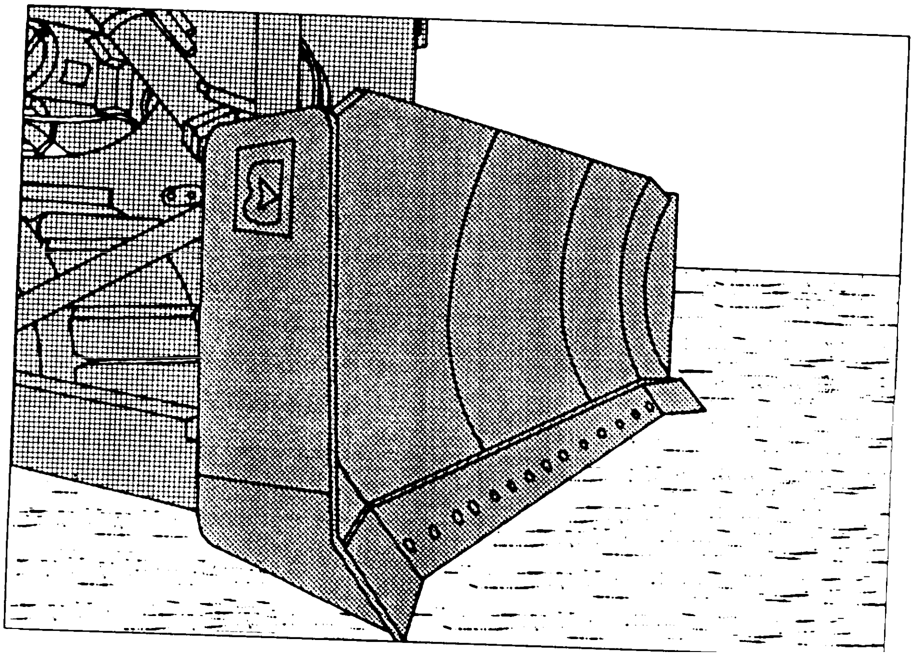


Figure 11-19.—"U" blade.

be drifted short to medium distances. Blade curvature lifts the dirt high with a rolling action to lower resistance and speed drifting. These blades have the side advanced ahead of the center section and tilt up to 15 degrees, right and left.

ANGLE BLADE.— The angle blade (fig. 11-18) is a multipurpose tool that can be used for general dozing and for the side casting of materials. The angle blade can be positioned straight ahead or angled 25 degrees to either side. The moldboard has a greater curve than a straight blade to produce more rolling action.

"U" BLADE.— The "U" blade (fig. 11-19) drifts large volume loads efficiently over long distances. The center section lifts material high with a forward roll. The side sections are angled so they lift and roll materials inward, keeping the load centered with a minimum loss of material to the side. This type of blade has the sides well advanced ahead of the center section, causing a "U" shape. It may also be tilted 15 degrees, right or left.

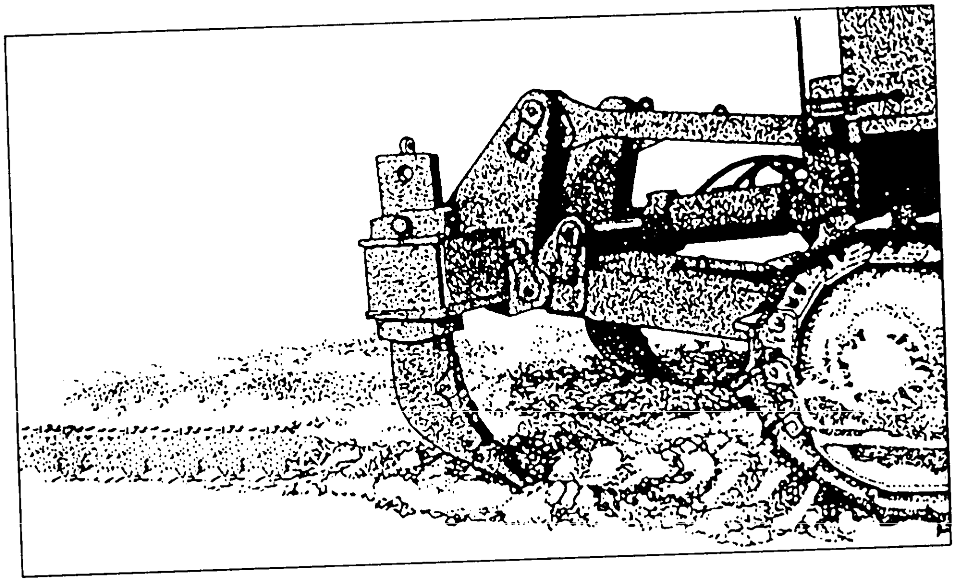


Figure 11-20.—Ripper attachment.

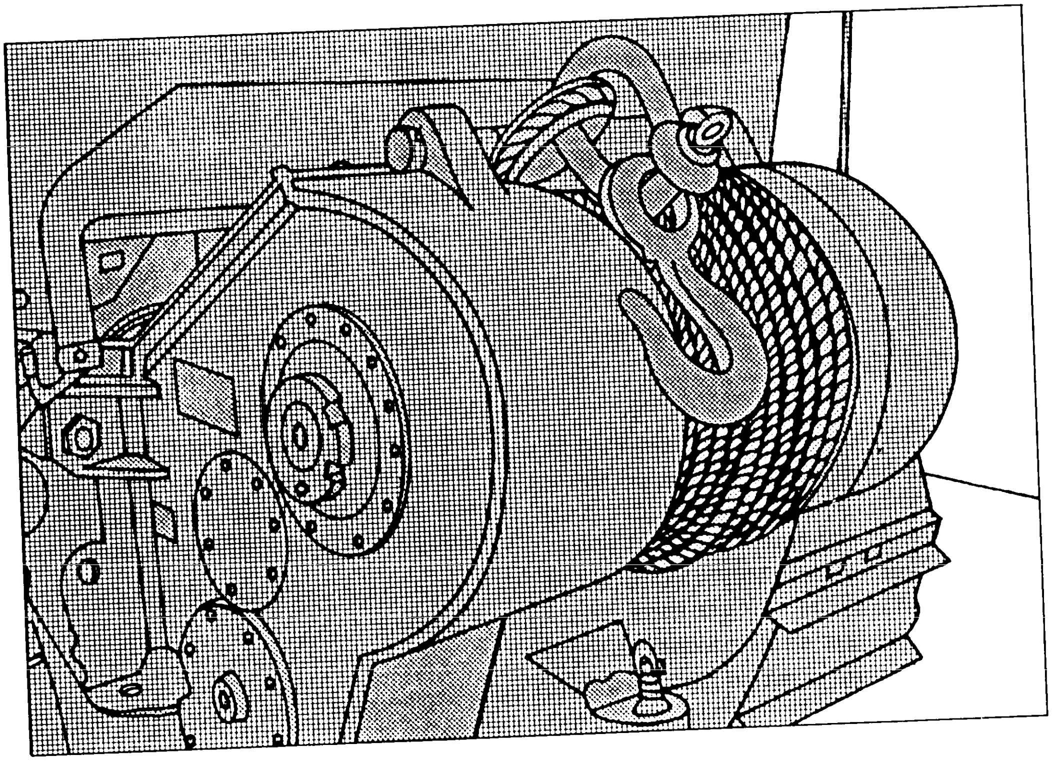


Figure 11-21.—Winch attachment.

Rippers

The ripper attachment is mounted on the rear of the dozer (fig. 11-20). The ripper is a powerful tool used to break up compacted materials; to uproot boulders and stumps; to loosen shale, sandsstone, and asphalt pavement; and to rip up concrete slabs. After these materials are uprooted or ripped, they can be removed easier by supporting equipment.

NOTE: Care should be taken when turning with the ripper teeth in the ground, because damage to the ripper teeth and assembly can occur.

Winches

A winch is mounted on the rear of the dozer (fig. 11-21) and is directly geared to the rear power takeoff. This arrangement permits development of a line pull that is 50 to 100 percent greater than straight dozer pull. The winch is used for uprooting trees and stumps, hoisting and skidding felled trees, freeing mired equipment, and supporting amphibious construction operations.

Some limitations to consider when performing winch operations are the pulling capacity of the winch and the size and weight of the dozer. Also, the terrain may affect maneuverability of the dozer.

WARNING

> The breakage of the wire rope is a serious hazard to both the operator and the helpers. Wire rope stretches under strain; and if it breaks, it whips with great force. The danger to the operator is greatest if the operator and dozer are in direct line with the wire rope when it is under strain. When the wire rope is under strain, **everybody in the area should stand clear of the full length of the paid-out wire rope.** When rewinding the wire rope back onto the winch drum, ensure riggers hands are clear of the winch drum by at least 3 feet. Be safety conscious and ensure the wire rope used is of the best quality and meets the manufacturers' specifications and is properly inspected before use. Always wear leather-palmed gloves when handling the wire rope.

A good practice is to work a winch at less than its maximum capacity and to avoid anchoring the dozer unless absolutely necessary. Moderate loads give long life to the wire rope and winch parts and avoid severe catching on the drum. If the work is heavy, strain can be reduced by the use of pulleys and multiple lines. When pulling from the winch, always be sure to pull straight off the winch. When wire rope is pulled from an angle, it slips sideways, possibly causing damage to both the wire and winch.

OPERATING TECHNIQUES

The dozer blade is hydraulically controlled by a lever in the operator's cab. Before starting, raise and lower the blade several times to get a feel of the hydraulic control. Start all jobs, if possible, from relatively level ground. If necessary, level an area large enough to provide sufficient working space for the dozer. This prevents back-and-forth pitching of the dozer and results in better blade control.

Avoid track spinning whenever possible; this wastes effort and only converts a relatively smooth working area into ruts and piles of material that pitch and tilt a tractor. In cold weather, ruts and piles freeze and cause additional difficulty the following workday. If it rains, the ruts hold the water, resulting in wet, muddy material.

Ditches, ridges, rocks, or logs should be crossed slowly and, impossible, at an angle. his procedure slows the fall, lessens the danger of upsetting the dozer, and reduces the jolt of the fall that can be harmful to both the operator and the dozer.

When dozing, shift the dozer into low gear and feed the blade into the ground gradually until the desired depth of the cut is obtained. When you feel an increase in resistance as the load increases, start raising the blade in small increments, about one-quarter inch at a time. If you raise and lower the blade as much as 2 or 3 inches at a time while operating, the blade cuts an uneven surface over which the dozer must travel. The uneven surface will cause the dozer to nose up and down. This causes the blade to cut still more unevenly, thereby increasing the up-and-down movement of the dozer.

To carry the load with the blade, you must anticipate and compensate for the up-and-down movement of the front of the dozer. When the front of the dozer starts to nose up, you should move the control lever in the direction that will lower the blade. When the dozer starts to nose down, raise the blade high enough to compensate for the lowering of the front of the dozer. Do not over control. Raise and lower the blade only enough to compensate for the raising and lowering of the front of the tractor. Through experience, you will be able to raise and lower the blade automatically without giving it much thought or special attention.

Clearing

Clearing consists of removing brush, trees, and rubbish from a designated area. Surface boulders and other material that may be embedded in the ground should also be removed as well as any material that may interfere with the construction project.

BRUSH AND TREES.— To clear brush and small trees with a dozer, travel forward at a slow speed with the blade lowered several inches below grade, as shown in figure 11-22. When cleared in this manner, make one pass to knock over small trees and brush, then make another pass to clear them away.

Medium trees are 4 to 10 inches in diameter. To push trees of this size, raise the blade as high as possible

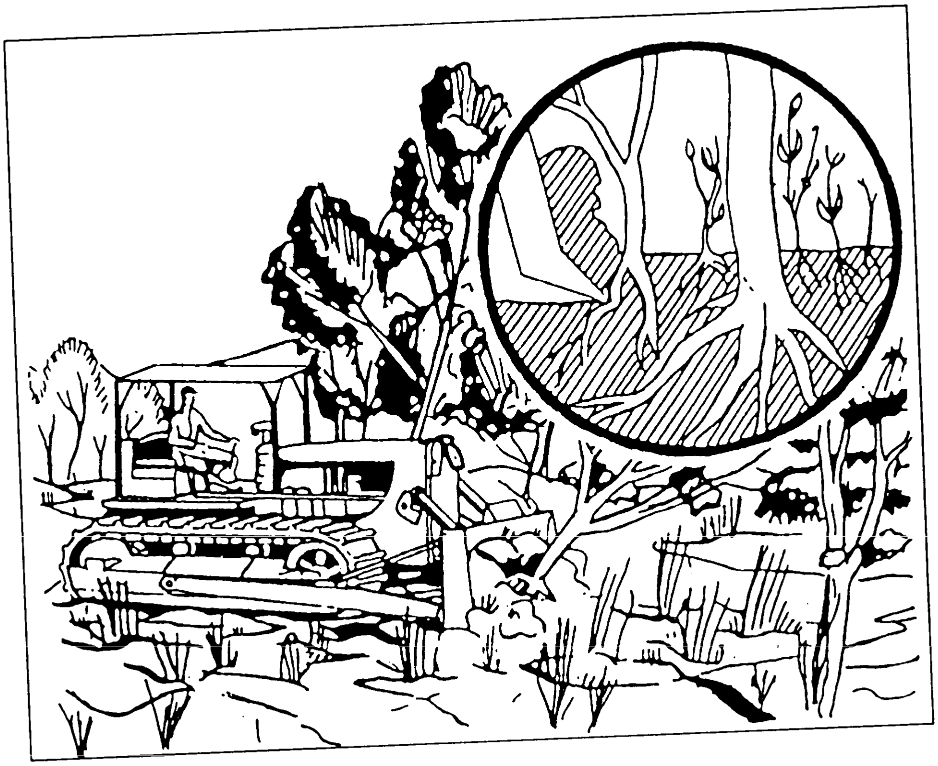


Figure 11-22.—Clearing brush and small trees.

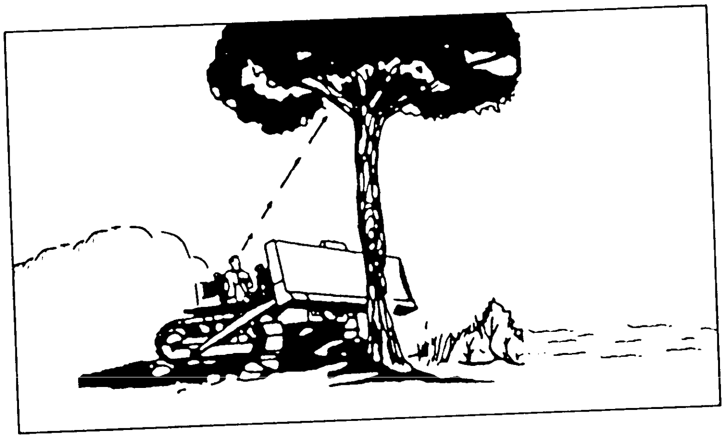


Figure 11-23.—Pushing over a medium-size tree.

to gain added leverage and push the tree over slowly, as shown in figure 11-23.

As the tree falls, backup quickly to clear the rising root mass. Lower the blade, travel forward, and dig the roots free with a lifting and pushing action. The felled trees are then ready to be pushed to a dismissal area.

Large trees are over 10 inches in diameter. For large trees, the removal is slower, more difficult, and takes more time. Approach the tree on foot and inspect it for dead limbs that could break off and fall on the dozer, possibly hitting the operator. Then make sure the dozer blade contacts the tree high and centered for the most leverage. Before pushing over a large tree, determine the direction of the fall, which is usually in the direction of lean. If the tree can be pushed over in the manner described for medium trees, do so.

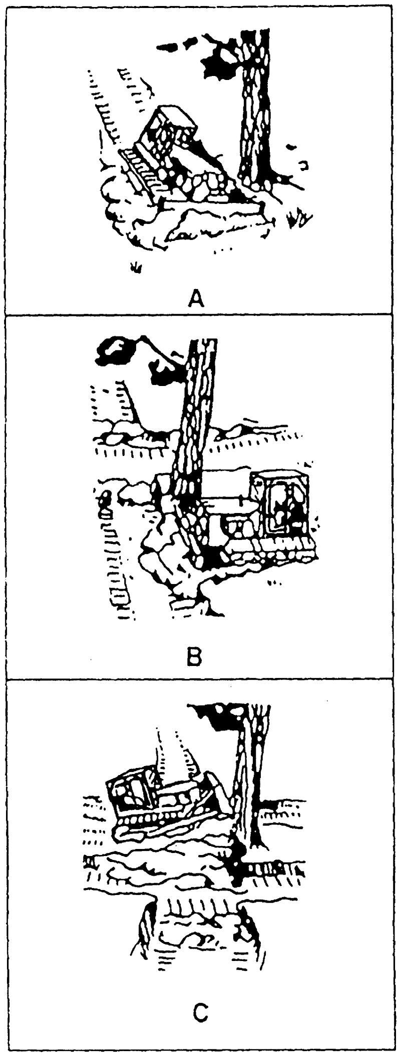


Figure 11-24.—Large tree removal.

If the tree has a large root system, the following method may be used: A cut is made on the side opposite the direction of fall of the tree to a depth sufficient to cut some of the larger roots (fig. 11-24, view A). The roots on both adjacent sides are cut in a similar manner (fig. 11-24, view B). Build an earth ramp above the original cut, so a greater pushing leverage can be obtained to push the tree over (fig. 11-24, view C).

As it starts to fall, back quickly to get away from the rising root mass. It may be necessary to cut the roots on the fourth side when large- or well-rooted trees are being removed. The cut around the tree should have a "V" ditch shape, made with the blade angled downward laterally toward the tree to cut the roots. The stump holes should be filled so water cannot collect.

CAUTION

> When removing trees, be careful not to injure personnel or damage equipment. See that the dozer has side covers for the engine. These covers help prevent limbs, sticks, and other debris from entering the engine area.

Dozers should never be worked close together when clearing trees, because one dozer could push a tree over on the other. Do not follow too closely when the tree starts to fall, since the stump may catch under the front of the dozer. The dozer will then need help backing off, and the bottom of the dozer could be damaged. As the operator, you should have a plan of how you are going to accomplish clearing the trees so they do not tangle with one another when they fall. You will probably be pushing green trees. They bend and snap back when free and may damage equipment or injure personnel. When making contact or releasing pressure on the tree, do it slowly so the top of the tree does not sway or shake, causing dead limbs to break off and fall on the dozer, possibly hitting you.

Know the ground on which you are working. Do not **high center** the dozer on stumps or trees. This problem is tougher when you are working in a wooded area and need help from another dozer. Existing trees could interfere. When you are clearing brush and trees, remember that the most common cause of damage to a machine is a stick or limb puncturing the radiator, breaking a hydraulic line, or damaging the exhaust stack. Pay attention. Know the capabilities of your dozer and what you need to do from start to finish.

STUMPING.— Pushing down a whole tree with a dozer is easier than removing the tree first by cutting it down and then removing the stump. The stump is usually too short to gain any pushing leverage or to provide a good swaying action for breaking out the roots.

When removing a stump, side cut deep enough to get the blade well under the roots. You can break up the roots by placing the blade well under the stump, traveling forward and raising the blade.

For a stump that will not yield to dozing, hauling it out with chains and grab hooks pulled by several dozers may work; or the stump may be hauled out by a wire leading to the winch on a winch-equipped dozer. If the ground around the stump is not to be disturbed, you may only need to saw the stump off level with the surface grade, rather than removing it.

REMOVING ROCKS AND BOULDERS.— A dozer with a tilted blade is the most effective piece of equipment for removing rocks and boulders. With the left lower corner of the blade hooked well under the boulder, the best way to exert maximum uprooting pressure is to combine raising the blade with a right turn of the dozer. With the right lower corner of the blade hooked well under the boulder, the best way to exert maximum uprooting pressure is to combine raising the blade with a left turn of the dozer. A boulder that is deeply embedded should beside cut, like a stump. Some boulders, like some stumps, must be broken up some other way for removal. If the dozer is not equipped with a hydraulic tilt control, the dozer blade can be tilted by adjusting the pitch braces on the blade of the dozer to lower either corner of the blade. To increase the digging action of a straight-blade dozer working in hard ground, tilt the top of the blade forward.

WORKING IN WET MATERIAL.— Wet material is quite difficult to move with a dozer. When the material is too soft to hold up the weight of the dozer, each successive pass should be the full depth of the wet material. This places the dozer on a firmer footing. The mud should be pushed far enough so it will not flow back into the cut. Provide for rescue of the dozer if the dozer gets stuck.

NOTE: Never pull a dozer forward by hooking onto the blade. The blade is made for pushing, not pulling, Hook the towing wire rope to the hook under the front of the tractor or to the drawbar on the rear of the tractor. Some dozers are equipped with wider track shoes for better flotation when working in mud or soft materials. These tractors with wide track shoes are called low ground pressure (LGP) tractors.

The extremely low ground bearing pressure is one of many reasons the dozer is highly recommended for working in wet materials.

Bulldozing

Bulldozing (drifting) is the process of pushing materials straight ahead in front of the dozer blade. Bulldozing is most efficient when the blade pushes as much material as possible, as shown in figure 11-25. The maximum working distance for dozer production depends on the speed and blade capacity of the dozer. However, the maximum working distance is usually 200 to 500 feet with 300 feet being normal for a medium-size dozer.

To maximize the amount of material pushed, push downhill whenever possible. With the assistance of gravity, a bulldozer can push a far greater load downhill than on a level grade. When you are dozing down a steep hill, a separate full-length pass with each load is unnecessary; instead, push and pile several loads at the brink of the hill and push them all to the bottom in a single pass.

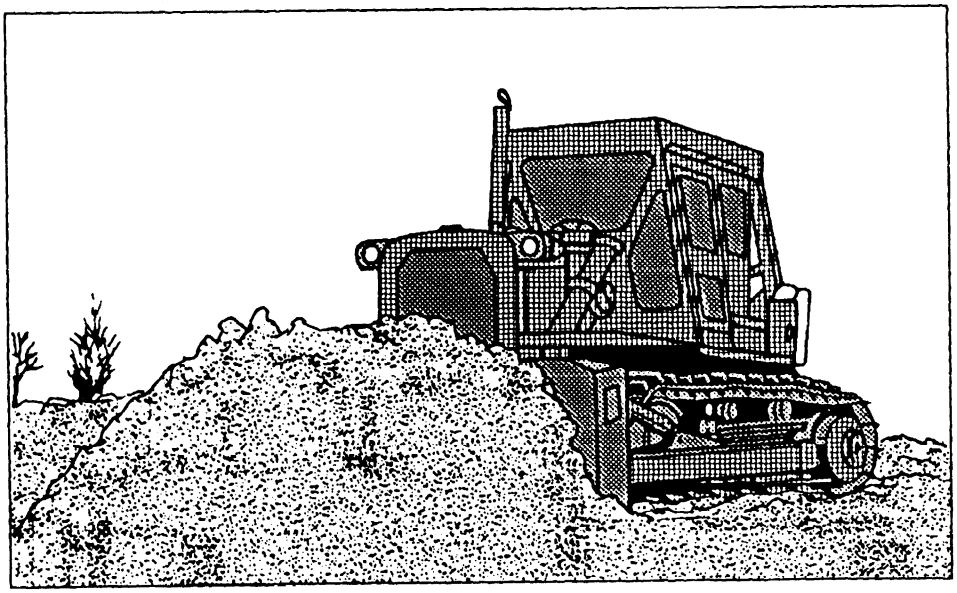


Figure 11-25.-Bulldozing.

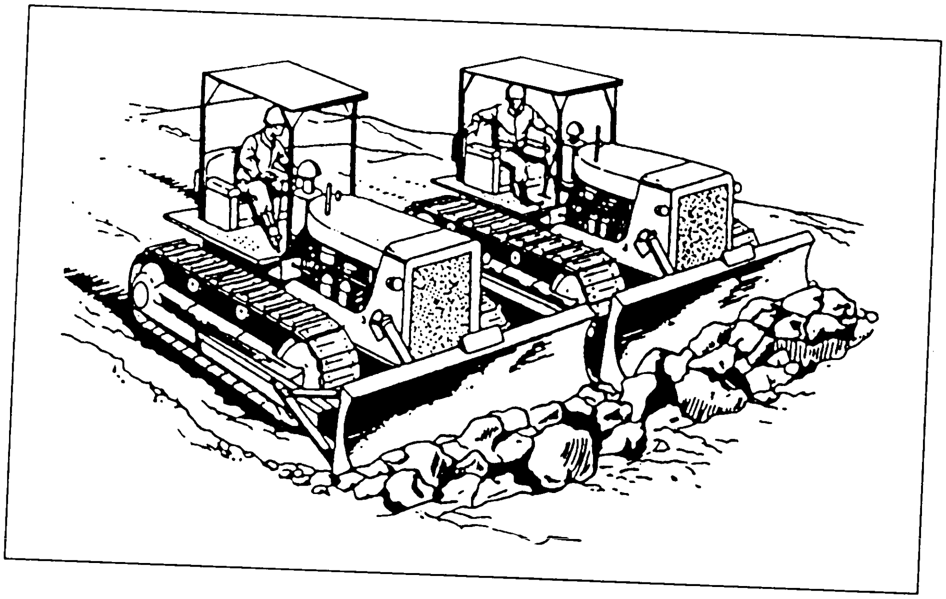


Figure 11-26.-Side-by-side dozing.

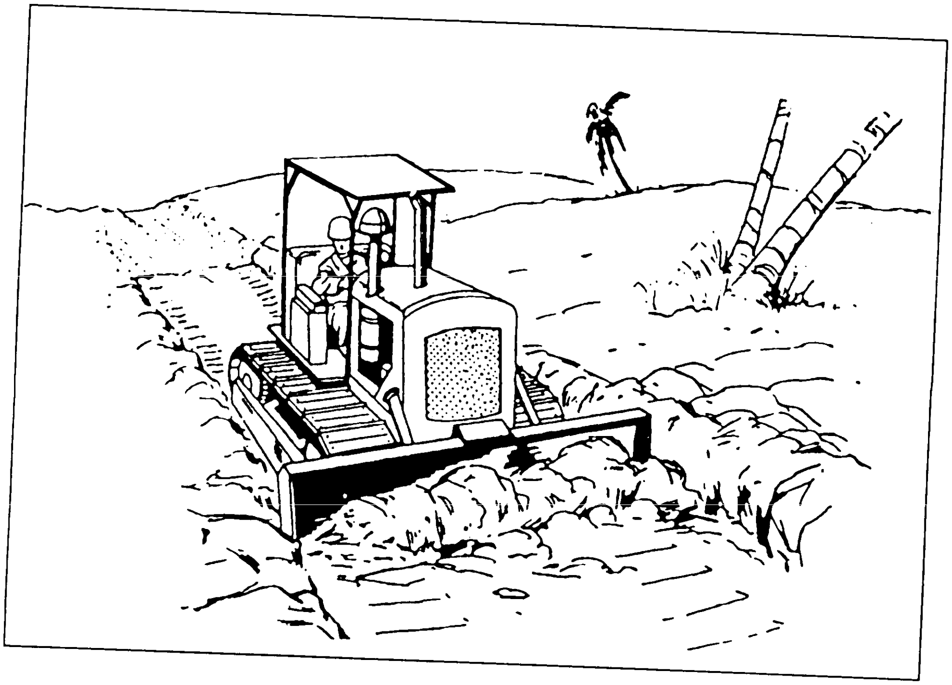


Figure 11-27.-Slot dozing.

Side-by-side dozing (fig. 11-26) and **slot dozing** (fig. 11-27) maximize the amount of earth drifted by reducing or preventing spillage around the outer edges of the blade.

SIDE-BY-SIDE DOZING.— In side-by-side dozing, two dozers work abreast with blade edges as close together as possible, preventing spillage around one blade edge on each dozer. Side-by-side dozing requires time-consuming maneuvering of the dozers; therefore, it is impractical for hauls of less than 50 feet and more than 300 feet.

SLOT DOZING.— Slot dozing is done by first building a pair of windrows with the spillage of several passes. As shown in figure 11-27, the windrows serve as barriers to prevent spillage around the dozer blade ends. Under favorable conditions, slot dozing can increase production up to 50 percent.

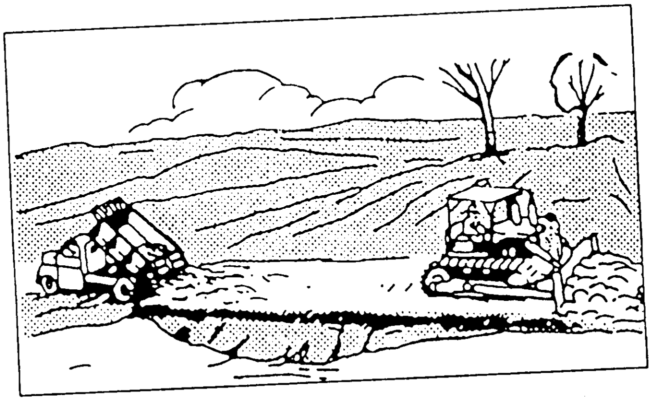


Figure 11-28.-Spreading.

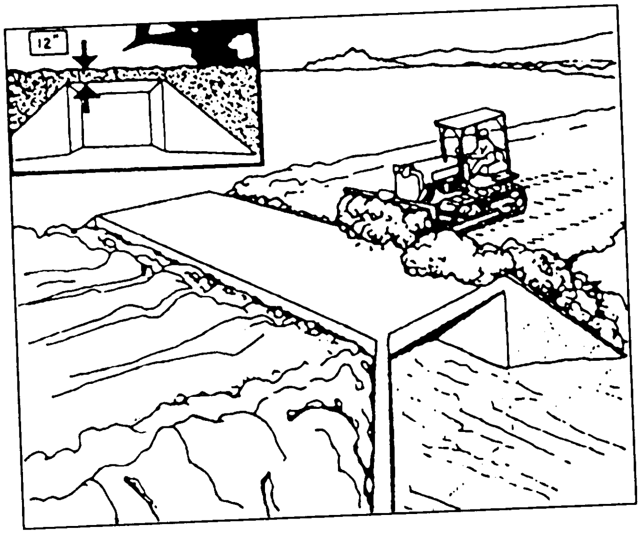


Figure 11-29.–Culvert backfilling.

SPREADING.— Dozers are ideal for spreading fill material brought in by haul units (fig, 11-28). Position the blade in a straight position, so the material is drifted directly under the cutting edge.

BACKFILLING.— Backfilling is the process of replacing excavated earth, as shown in figure 11-29. When a culvert is backfilled, the dozer should not cross the culvert unless there is at least 12 inches of compacted material on top of the culvert. If a bulldozer is used to bacfill a culvert, the best method is to make diagonal passes over the material, ending each pass with a swing that brings the blade in line with the culvert.

The **angle blade** is preferred for bacfilling a trench, because material can be side cast into the trench while maintaining a steady forward motion, as shown in figure 11-30.

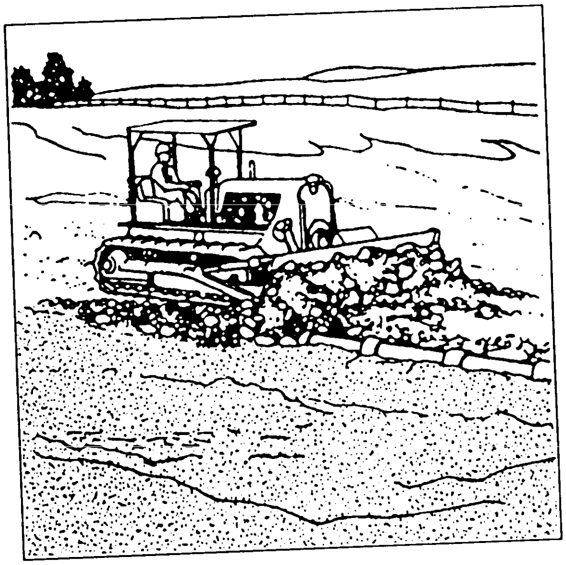


Figure 11-30.Trench backfilling.

When a pipe trench is bacfilled, fine material is placed around the pipe and coarse material above it, so the pipe is supported by well-compacted material. However, covering the pipe to full depth in short lengths may concentrate weight and break pipe joints; therefore, cover the pipe in successive layers, rather than all at once.

NOTE: Be careful in pipe trench bacfilling to avoid dropping large rocks directly on the pipe.

FINISHING.— Whether clearing or spreading material on a roadbed, no job is completed until it has been smoothed and drainage is established. This is called **finishing** and should be done at the end of each Shift.

Blade the job lightly with about a half of a blade of dirt. This fills in any low spots or holes. Leave a windrow on the side that you are working toward. At the start of the next pass, cover half the blade width. Continue in this fashion over the project or section of the project you have worked that day before you shut down for the day. Finishing the project in this manner supports drainage and prevents having to walk over piles of dirt or through mudholes.

Ditching

Rough ditching can be done with a dozer by making a series of overlapping passes at right angles to the line of the ditch. A "V" type of ditch can be dug with a dozer as follows: First, buildup a windrow along the edge of

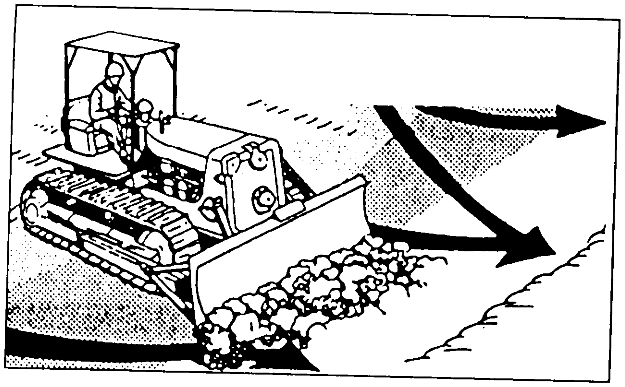


Figure 11-31.—"V" ditch construction.

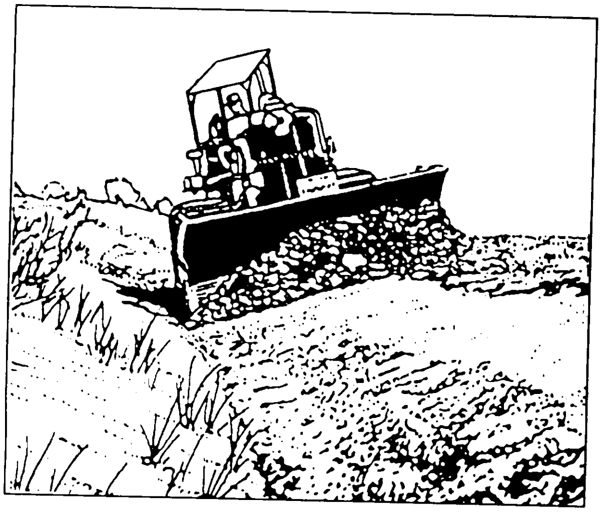


Figure 11-32.-Angle blade ditch cut.

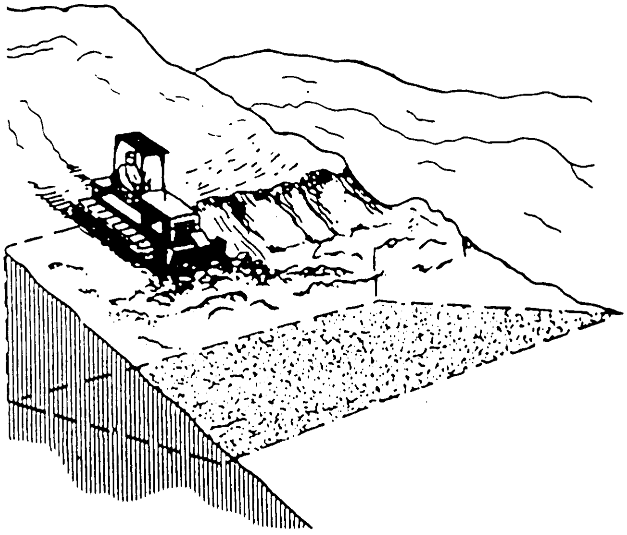


Figure 11-33.—Bench cut.

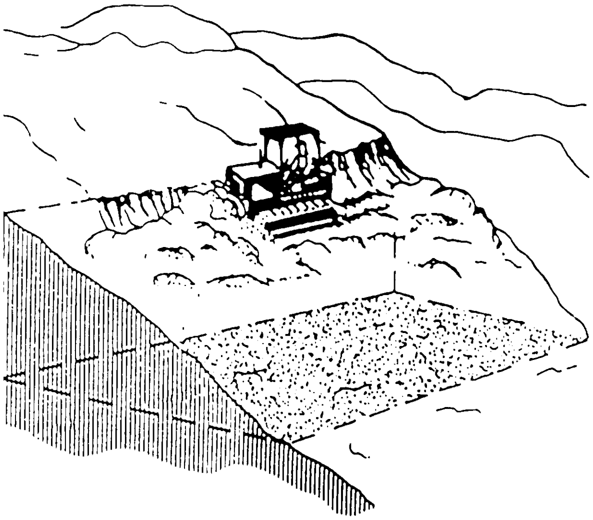


Figure 11-34.-Sidehill excavation.

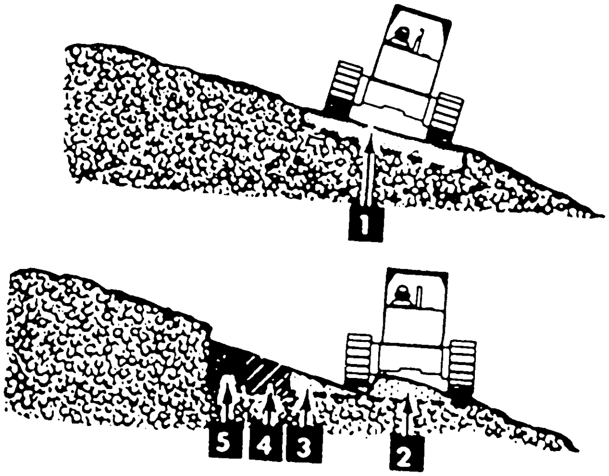


Figure 11-35.-Shallow slope sidehill excavation.

the ditch (fig. 11-31). Then turn the machine parallel to the line of the ditch, get the outside track on the window, and make a pass along the windrow. With the outside track elevated by the windrow, the blade cuts one side of a "V" type of ditch. Cut the other side the same way.

An **angle blade** is preferable for digging a "V" type of ditch for two reasons: (1) you can side cast the windrow in a single pass and (2) the angled blade will side cast the material to the sides of the ditch as you travel along the windrow, as shown in figure 11-32.

Sidehill Excavation

A sidehill excavation can be started more easily if a small bench cut is made first, as shown in figure 11-33. When digging the sidehill, keep the inside (uphill) surface slightly lower to gain greater tractor stability (fig. 11-34). Tilting the blade produces this type of cut.

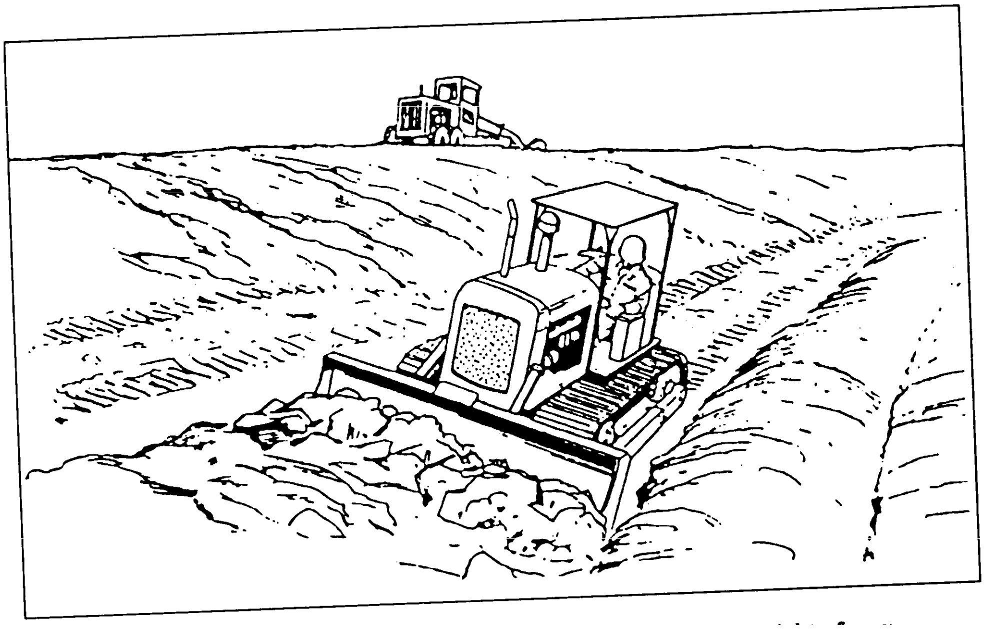


Figure 11-36.–Finishing a side slope by working parallel to the right-of-way.

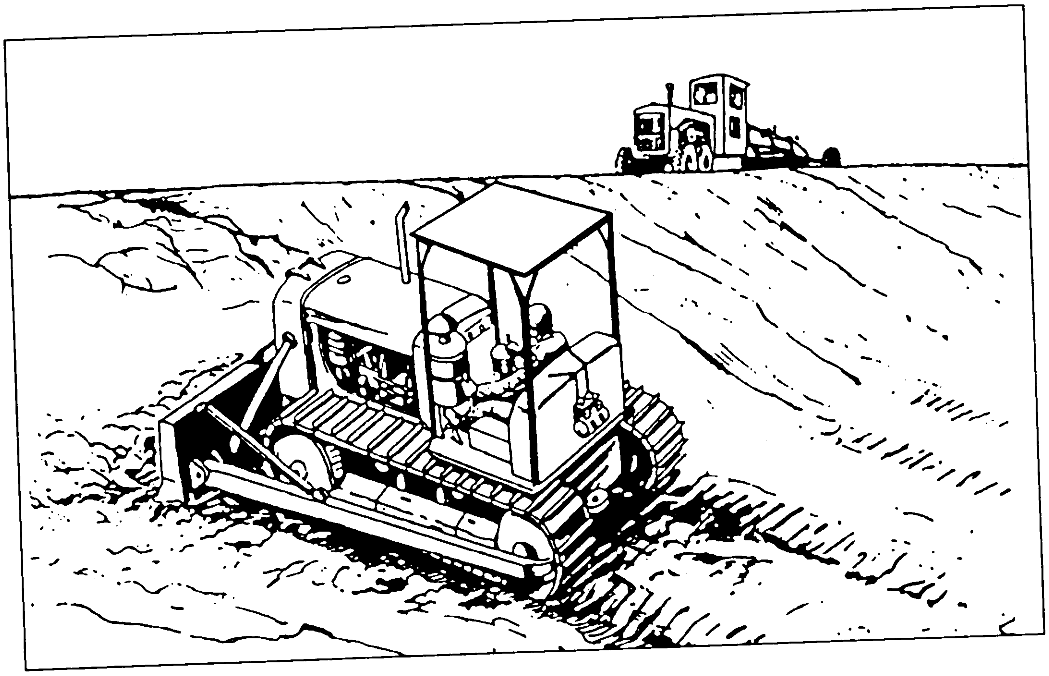


Figure 11-37.–Finishing a side slope by working diagonally.

Always cut the shelf wide enough to provide solid support for equipment that will be used later. If possible, move the material downhill to gain the advantage of gravity, to reduce effort, and to increase the stability of the dozer.

On shallow slopes or in soft soil, the sidehill cut can be made, as shown in figure 11-35, cuts 1 and 2.

Stability is increased by running the uphill track inside the ridge left by the first cut. Cuts 3, 4, and 5 show the completion of the shelf. Pushing the loosened material to the lower side of the slope normally reduces the time required to complete the cut. Do not push the material beyond the point required to retain firm track support. When you are backing up, do not raise the blade, as this puts extra weight on the front idlers, causing greater track penetration. Let the blade float as you back away from the edge of soft fills.

Finishing Side Slopes

Two commonly used methods for finishing side slopes with dozers are shown in figures 11-36 and 11-37.

When side slopes are finished by working parallel to the right-of-way (fig. 11-36), the dozer starts at the top. Material from each pass falls to the lower side of the blade and forms a windrow that is picked up on succeeding passes, filling irregularities in the terrain. Do not allow the blade corner to dig, since this steepens the slope beyond job specifications. In finishing side slopes by working diagonally, start the dozer at the bottom and work diagonally up the slope (fig. 11-37). A windrow is formed and is continually drifted to one side, tending to fill low spots or irregularities.

NOTE: Diagonally finishing a side slope is one of the few instances when a dozer maybe used efficiently in cutting upgrade.

Push Dozer

The push dozer in figure 11-38 is equipped with a push blade. However, in most cases, a straight-blade dozer that has a reinforced block in the center of the blade is used. Ensure the center lines of the pusher and scraper are aligned. If alignment is not centered, it is hard to keep the pusher straight without extensive use of the steering clutch. When you are using the steering clutch, power is taken away from one track, and the other track is doing all the work. If the scraper starts to jackknife, stop pushing, back up, and get repositioned straight with the scraper. Be sure the blade of the dozer does not cut the rear tires of the scraper, resulting in downtime and costly tire replacement.

Dozer Safety

Standard safety precautions that apply to dozer operations are as follows:

- Only operate the dozer at speeds at which control of the dozer can be maintained at all times.

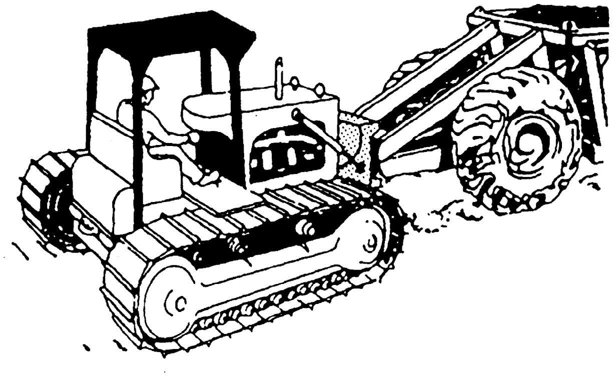


Figure 11-38.—Push dozer.

- Navy safety regulations require that all dozers be equipped with roll-over protective strictures (ROPS), crankcase guards, and radiator protectors. All dozers purchased by the Navy are equipped with these devices. Dozers must never be used without these devices in place.
- Always wear a seat belt when dozing. A sudden jolt from working on uneven terrain can possibly throw you off the machine or against the control levers, causing serious injury or death.
- Obtain a digging permit before performing excavation operations with a dozer.
- When using a dozer for demolition, take care to prevent falling objects from striking the operator or other personnel.
- When felling trees with a dozer, take care to avoid being struck by falling branches or by the backlash of a branch or trunk.
- A dozer should never be used for clearing trees without being equipped with an operator's protective cage (brush cage).
- Personnel must never ride the dozer drawbar. his dangerous practice has been the cause of numerous accidents.
- Operators of dozers and rippers should make every effort to learn the locations of any underground high-voltage electric lines or gas lines that might be contacted by their equipment.
- Operate the dozer from the sitting position, never from a standing position.
- A dozer must be operated with extreme care when near the edge of a cut; the edge may give way, overturning the machine.
- A steep incline should be climbed slowly. "Gunning" up a steep slope has often caused dozers to overturn.
- Do not attempt a turn on a steep slope. Sliding sideways may not appear to be dangerous, but it can easily become so if the low side of the dozer hits a solid rock or a stump.
- Coupling trailing equipment to a dozer is hazardous; be especially alert while this is being done. Whenever possible, equipment should be coupled with the dozer stopped and the clutch, if so equipped,

disengaged. Additionally, set the brake, and lower the blade.

- When towing a heavy load downgrade, keep the dozer in low gear. Coasting is dangerous. A coasting dozer with a towed load is likely to jackknife.

- Before dismounting a dozer and at the end of a workday, secure the dozer blade by lowering it to the ground. Lowering the blade prevents the dozer from rolling; more importantly, it eliminates the possibility of the blade falling on someone. Whenever it is necessary to work on the dozer with the blade up, especially when changing cutting edges, the blade must be securely blocked to prevent it from falling accidentally.

- Wear required personal protective equipment, such as steel toe safety shoes and hard hats.

ROLLERS

Any time soil is disturbed, it becomes expanded and very loosely packed. During the construction of a fill or subgrade, this loose soil must be compacted into a solid mass. The process of compressing The loose soil into a solid mass is called compaction. If the soil is not properly compacted during construction, it will settle causing roads, building foundations, or runways to collapse.

Soil may be compacted naturally (settled) by weather and time. If the soil is porous, settlement may be speeded by soaking it and allowing it to dry. This process is slow and cannot be depended upon to produce the high densities required by project specification. Another method of compaction is through chemical stabilization that involves the application of one or more chemicals to a soil to achieve a desired change in its characteristics. Mechanical compaction is normally required to supplement chemical stabilization. To accomplish mechanical compaction, you can use various compaction techniques and types of compaction equipment, such as vibratory rollers, pneumatic-tired rollers, and steel-wheeled rollers.

VIBRATORY ROLLERS

Vibratory rollers provide compactive force by a combination of weight and vibration of their steel compaction rolls, commonly referred to as drums. Those used for compaction are self-propelled and vary in weight from 7 to 17 tons.

Propulsion for single-drum models is provided by pneumatic-tired wheels, as shown in figure 11-39. The

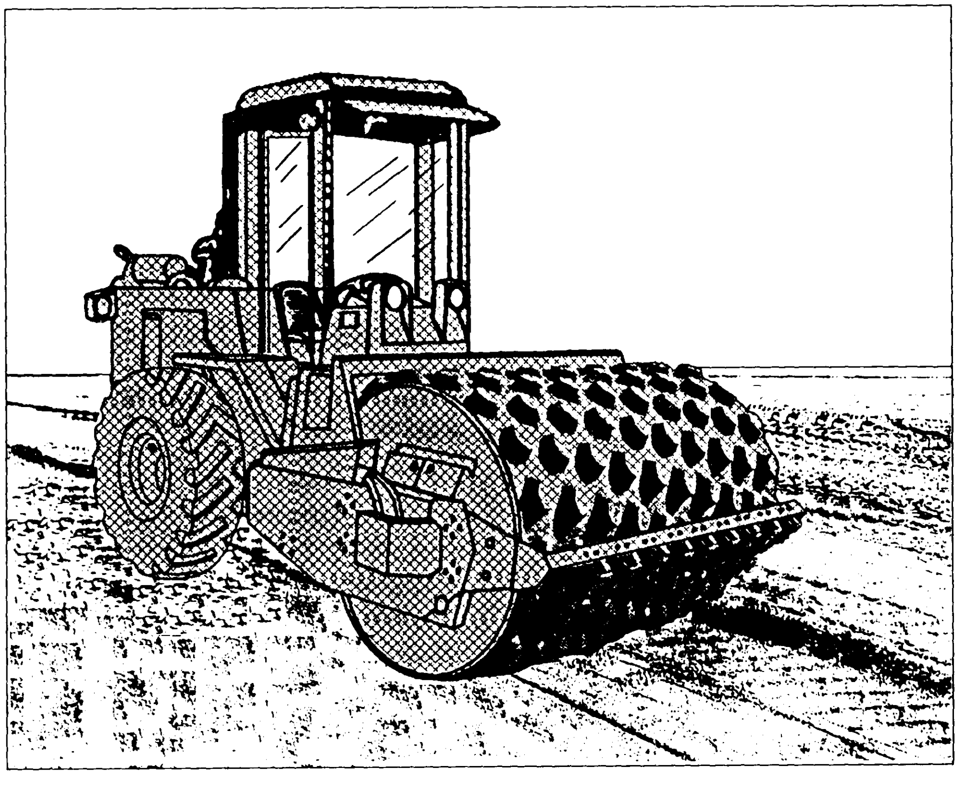


Figure 11-39.—Vibratory roller.

drums on vibratory rollers vary from 3 to 5 feet in diameter and 4 to 8 feet in width.

The engine, providing power for propulsion, also powers the hydraulically driven vibrating unit. Vibrations are generated by a rotating eccentric weight inside the drum, the speed of which determines the frequency, or vibrations per minute, of the drum. The weight and distance from the shaft of the eccentric determine the amplitude (amount) of the impact force. Both the frequency and amplitude of vibrations are controlled independently of roller travel and engine speed.

The vibration frequency of rollers used for compaction is generally between 2,000 to 3,000 vibrations per minute (vpm), depending on the model and manufacturer. Some models provide only one or two specific frequency settings; while others may provide a full range of frequencies within certain limits; for instance, 1,800 to 2,400 vpm.

Vibratory rollers achieve compaction through a combination of three factors: (1) weight, (2) impact forces (roller vibration), and (3) vibration response in the soil.

Weight

Weight is the natural force in compaction of soils. Vibrating rollers amplify their static weight through vibration to increase the overall dynamic weight.

Impact Forces

The impact forces are those generated by vibration of the compaction drum. They are regulated by controlling the frequency and amplitude of the vibration. The amount of impact force required to obtain optimum density depends on the type of material being compacted. The impact forces also vary with the diameter of the drum and the width and the ratio of the roller static weight and dynamic (impact) force.

Vibration Response

The vibration response in the soil or material is the result of the way the forces are exerted upon it by the vibratory roller. As with other types of rollers, the material will compact easily or with difficulty, depending on its moisture content, cohesion characteristic, particle shape and texture, and confinement; for example, sandy soil requires more vibration and less impact force (amplitude). However, a soil with higher clay content requires more amplitude than vibration because of the kneading action necessary to compact the clay. Vibratory rollers exert repetitive dynamic force on the material, rather than the static force used by other rollers.

The frequency and roller speed should be matched, so there will be at least 10 downward impacts per foot of travel of the roller. The speed of the roller increases for a given frequency of vibration, and the spacing of the impacts grows farther apart.

When using vibratory equipment, keep in mind that the energy imparted by the vibratory wheel must be absorbed in the material being compacted. Controlling the amplitude permits the operator to vary the force developed from the wheel and, therefore, the energy imparted to the material. A change in the lift thickness and material gradation content may require adjustment in the amplitudes being used.

NOTE: It is important that the roller vibrates only when it is moving. If vibration continues while the roller is standing still or changing direction, the vibrating drum will leave an indentation in the material at the stopping point.

Most modern rollers have automatic cutoffs for vibration when the roller stops moving.

The rollers used in the Naval Construction Force (NCF) are equipped with two interchangeable drums. One is known as the **sheepsfoot,** as shown in figure 11-40; and the other is known as a **smooth drum,** as shown in figure 11-41.

Sheepsfoot Drum

The sheepsfoot drum is used for compacting heavy lifts of 6 to 12 inches thick. As consecutive passes are made, the drum will start to walk out of the ground as the penetration of the sheepsfoots decrease. These rollers should only be used for initial compaction, because the footprints they leave will not allow excess water to drain.

These rollers concentrate the static and dynamic weight on the relatively small contact area of the sheepsfoots. This force is exerted through the one row of feet in contact with the ground. With all the roller weight concentrated on this row of sheepsfoots, they exert more than 22,000 pounds of force.

Smooth Drum

In most heavy fills, a smooth drum roller is worked behind the sheepsfoot drum and grader. With thinner

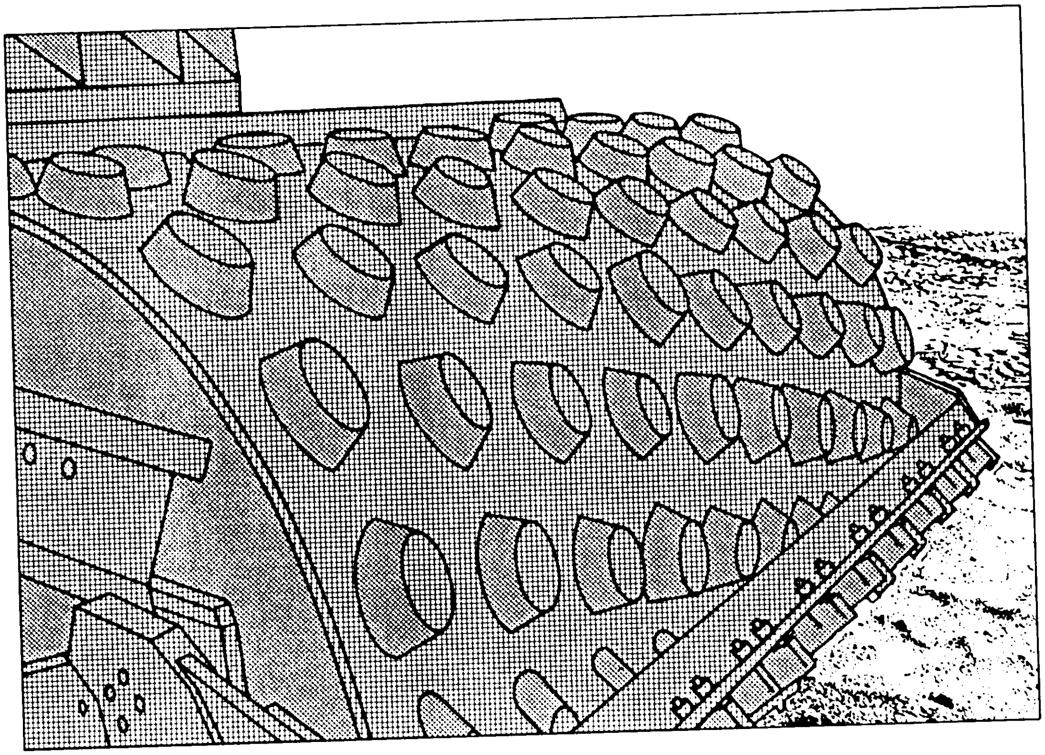


Figure 11-40.-Sheepfoot drum.

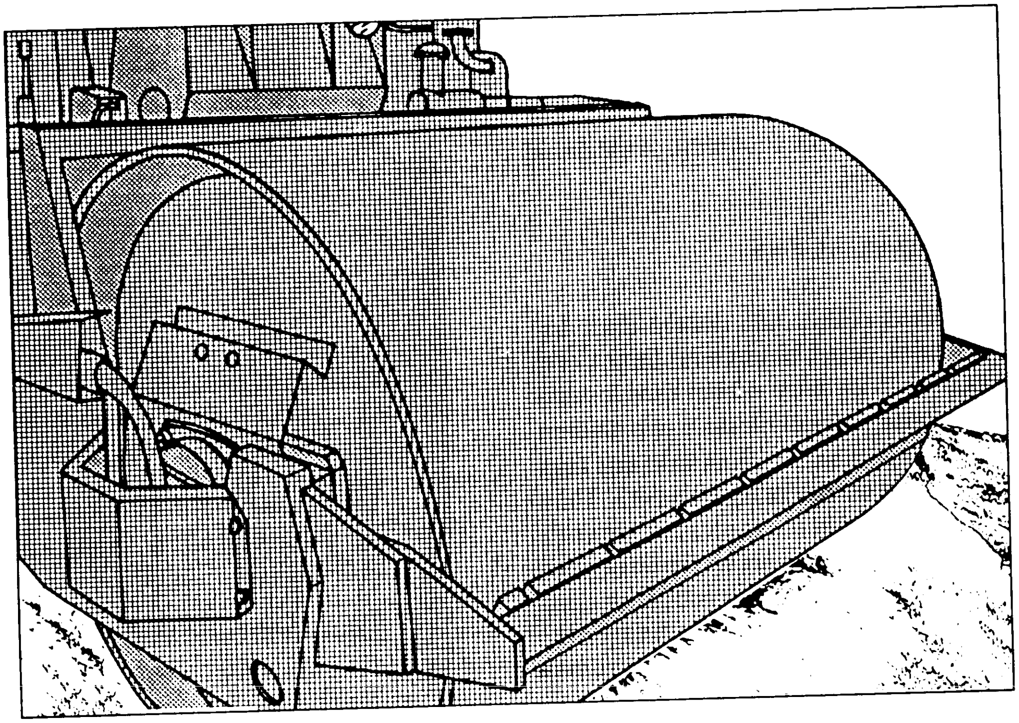


Figure 11-41.-Smooth drum.

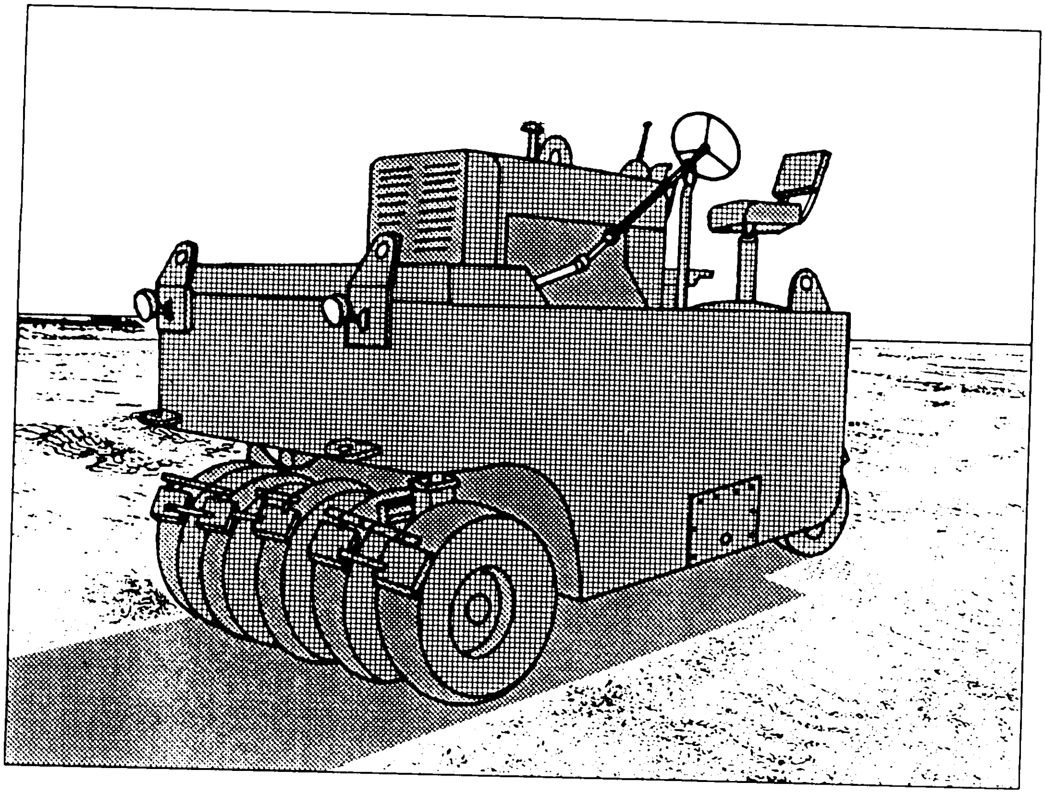


Figure 11-42.—Pneumatic-tired roller.

lifts, a smooth drum is all the compaction equipment required. The smooth drum compacts lifts of 4 to 8 inches and seals the surface to allow the excess water to drain. Unlike the sheepsfoot drum, smooth drum rollers concentrate the full width of the drum. The total dynamic force is slightly less, because more of the drum is in contact with the ground.

PNEUMATIC-TIRED ROLLERS

The pneumatic-tired rollers are widely used for compaction of subgrades, bases, bituminous mixes, and many types of material. They have rubber tires instead of steel tires or drums and generally feature two tandem axles, with three or four tires on the front axle and four or five tires on the rear, as shown in figure 11-42. They are aligned so the rear tires cover the spaces left between the tracks of the front tires. The tires are mounted in pairs that can oscillate, or singly with spring action, so tires can move down into soft spots that would be bridged by a steel drum. The rubber tires add to their downward pressure a **kneading effect,** as material is pressed toward spaces between the tires.

Pneumatic-tired rollers can be ballasted to adjust the weight. Depending on size and type, the weight may vary from 10 to 35 tons. However, more important than gross weight is the weight per wheel for the material being compacted.

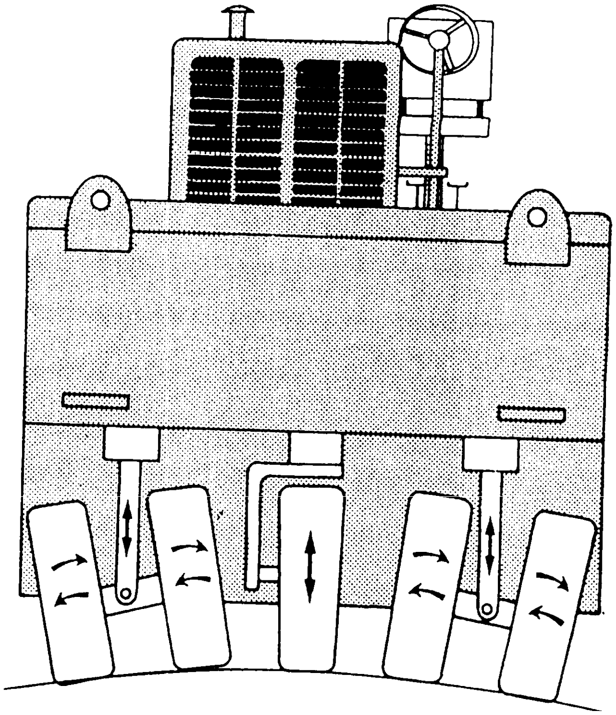


Figure 11-43.—Action of a pneumatic-tired roller.

CAUTION

Pneumatic rollers ballast with water are top heavy and are very unstable when operating on uneven terrain.

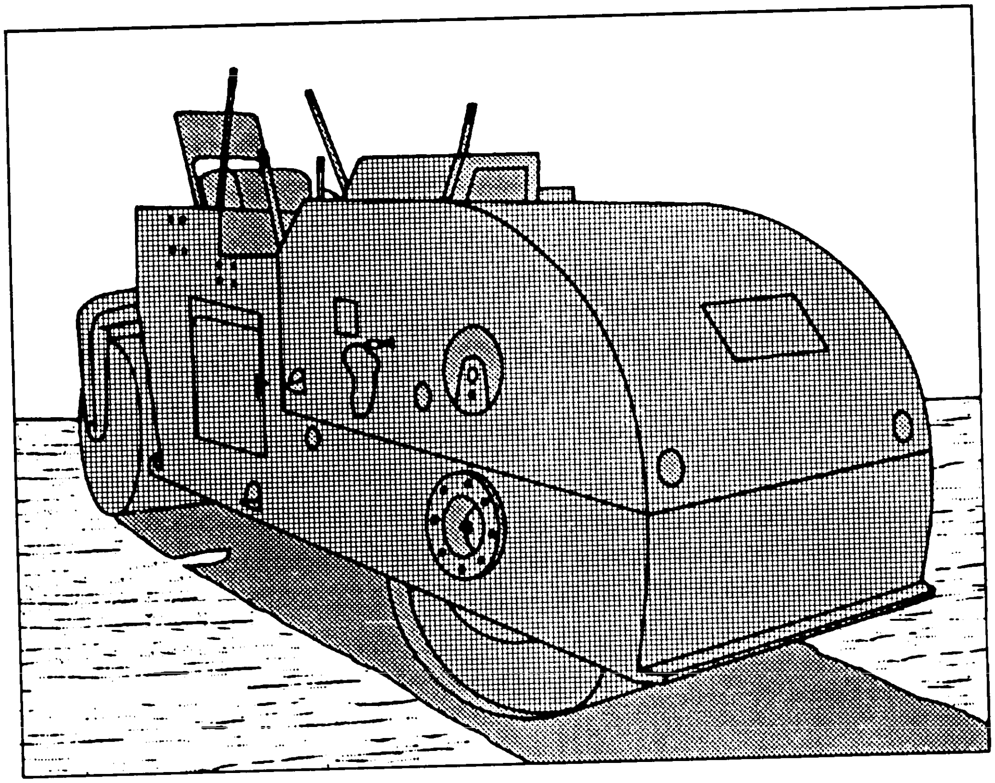


Figure 11-44.-Steel-wheeled roller.

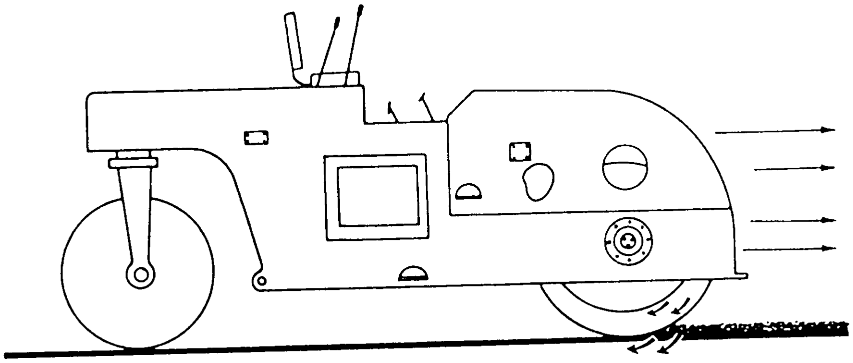


Figure 11-45.—Drive wheel rolling action.

Pneumatic-tired rollers may be equipped with 15-, 17-, 20-, or 24-inch tires. Air pressure in the tires may vary for different types of material, such as 50 to 60 psi to finish asphalt and 100 psi to compact a granular subbase. The tires must be inflated to nearly equal pressure with variation not exceeding 5 psi to apply uniform pressure during rolling.

Figure 11-43 shows the action of a pneumatic-tired roller. Pneumatic-tired rollers are used because the individual wheels can exert a kneading action in small areas that wide, rigid steel drums tend to bridge.

STEEL-WHEELED ROLLERS

A steel-wheeled roller, as shown in figure 11-44, is used for compaction and finish operations on base coarse materials and asphalt. This roller produces a smooth, solid surface under favorable conditions, but may fail to compact areas narrower than the roll, and do not compact deeply in proportion to their weight. The steel- wheeled roller does not change shape to bring suitable support for itself. Rather it sinks until enough bearing area has come in contact with the roll to support the roller weight.

The drive wheel is ahead of the tiller wheel in the direction of travel. The tiller wheel functions as the steering axle. As shown in figure 11-45, there is a downward vertical force caused by the weight or the wheel. The arrows, concentric with the steel wheel, represent the rotational force on the wheel. This force is transmitted to the base of the wheel, as the roller is propelled. This concentric force tends to move the material under the wheel, rather than to push it away. These forces result in a more direct vertical force than those of the forces under the tiller wheel.

ROLLING TECHNIQUES

Roller techniques arc basically the same with any type of roller. Some things you must consider are steering, changing direction and speed, and rolling sequence.

Steering

Steering sharply causes scuffing and damage to the surface; therefore, turns should be made slowly and gradually. You may have to back up several times to complete a turn.

Changing Direction and Speed

Starting and stopping should be done gradually to avoid scuffing the surface. Start stopping well ahead of the point where you want to stop. Engage the direction control slowly to avoid any wheel spin.

Rolling speed is 1 1/2 to 3 miles an hour. You must develop a rolling sequence to ensure the compaction is uniform throughout the fill.

Rolling Sequence

Overlapping is part of the rolling sequence. When rolling deep, loose fills, you should overlap at least half the drum width. Gradual extension of the rolled material into the unrolled area makes possible greater concentration of weight on local ridges and high spots.

In rolling a graded area with a side slope, as a crowned or banked road, you should work from the bottom to the top. The lower edges of the rolls have a tendency to push downhill, which can be best resisted by compacted material. In working uphill, the creep of soil away from the upper edge helps to preserve the slope.

A crowned road is rolled according to the pattern shown in figure 11-46, starting at one edge and working to the center line. Then move diagonally to the opposite side and work to the center line from that side. Each rerolling is done in the same manner.

It is efficient to roll in sections as long as you can overlap the sections, as shown in figure 11-47.

Banked or sloped elevated curves are rolled in the direction of travel, from the bottom (low side) to the top, as shown in figure 11-48. The rolling transition from the road crown to the bank curve is made by a diagonal from the center of the crown to the low side of the bank. The rolling transition from bank to crown is made straight to the adjoining low side of the road crown.

Rolling should be continued until no compaction advantage is noted on the fill from successive passes. Too much water in the fill material may make compaction impossible. This may require scarifying and windrowing the fill to aerate the material. A rubbery, or spongy, rolling action of the fill that springs back into nearly its original condition when the rollers have passed may indicate trapped water below the surface. The robbery, or spongy, area may require stabilization by other means, such as excavating the area and

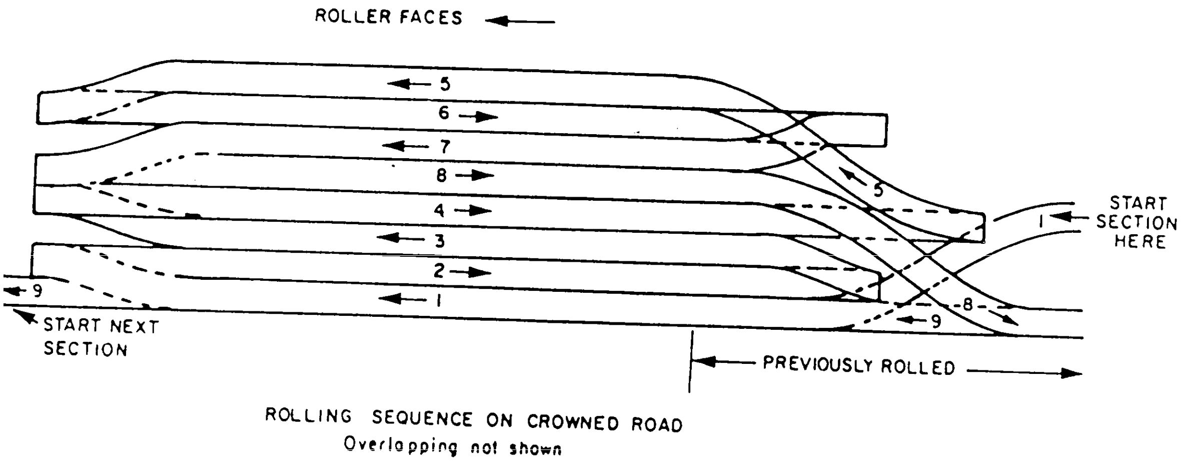


Figure 11-46.-Crowned road rolling sequence.

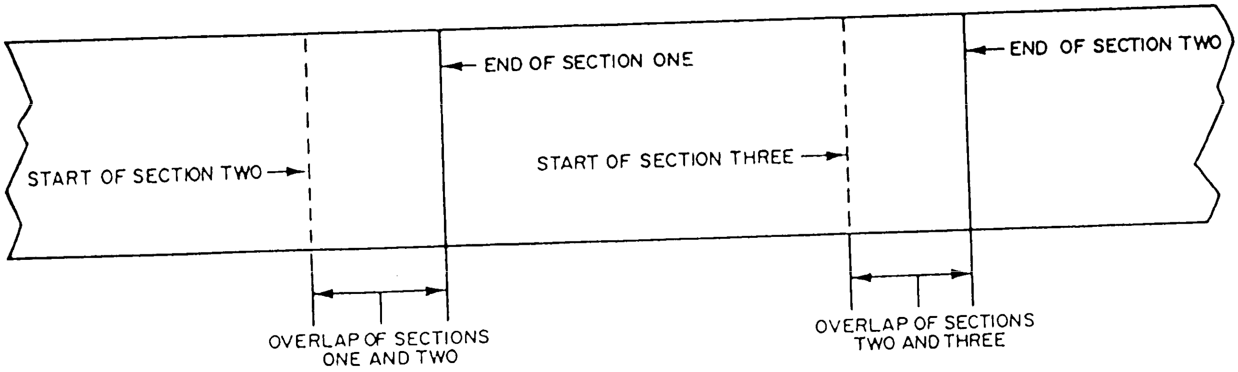

END OF SECTION ONE
END OF SECTION TWO
START OF SECTION TWO
START OF SECTION THREE
OVERLAP OF SECTIONS ONE AND TWO
OVERLAP OF SECTIONS TWO AND THREE

Figure 11-47.-Overlapping sections.

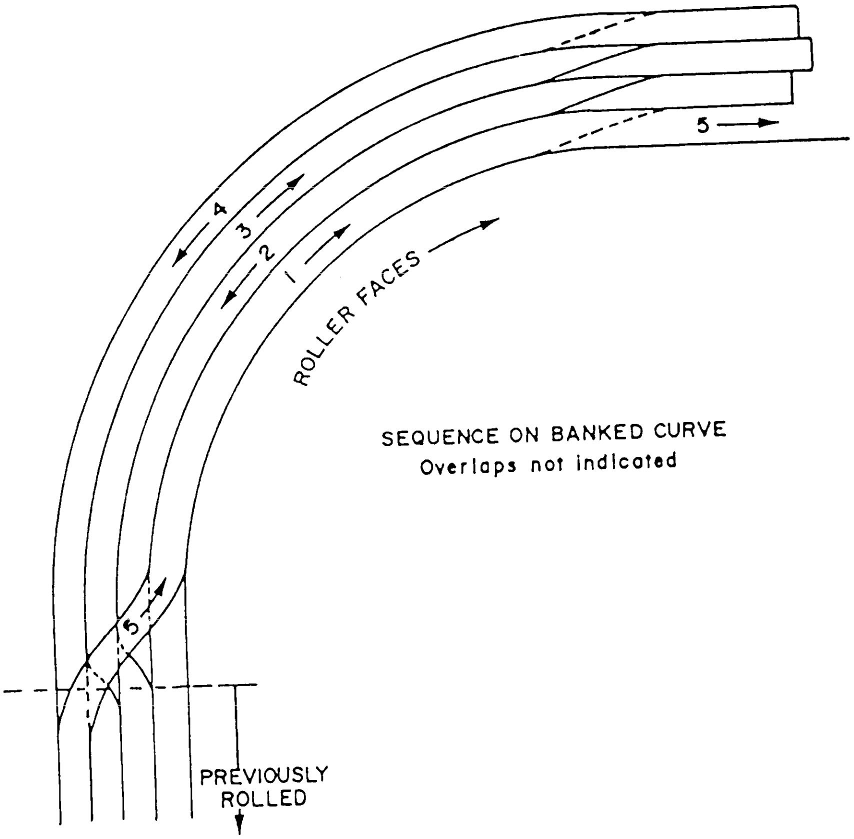

1
2
3
4
5
5
ROLLER FACES
SEQUENCE ON BANKED CURVE
Overlaps not indicated
PREVIOUSLY ROLLED

Figure 11-48.—Banked curve rolling sequence.

placement of riprap, soil cement, asphalt stabilization, and so forth.

BITUMINOUS ROLLING

Most of the compaction required in bituminous construction is achieved by the tamper on the asphalt paver. Additional compaction and final surface texture are achieved by applying the rollers in the proper sequence. The hot mix should be at its optimum temperature for rolling when the rollers start to operate on the mat being laid. This optimum temperature should range between 225°F to 285°F.

Rollers designed for bituminous operations are equipped with sprinklers that spray water on the smooth tires and drums. When you are rolling bituminous materials, the roller tires and drums must be moist with water to keep the bituminous materials from sticking. When water is not enough to keep the bituminous material from sticking, a non-foaming detergent is added to the water until the water has a soapy feeling.

NOTE: Do NOT use a detergent that is designed to break down grease or oil, as this will break down the petroleum products used in the bituminous mix.

NOTE: Ensure roller tires and drums are free of debris, such as sand, mud, dirt, and so forth, before rolling a hot bituminous mix.

CAUTION

> Avoid prolonged skin contact with and inhalation of vapors from bituminous operations.

When you are rolling bituminous materials, the rollers should move at a slow, uniform speed with the drive wheels positioned toward the paver. The speed should not exceed 3 mph for steel-wheeled rollers or 5 mph for pneumatic-tired rollers. Asphalt rollers must be kept in good condition and should be capable of being reversed without backlash. The line of rolling should not be suddenly changed or the direction of rolling suddenly reversed, thereby displacing the mix. Any pronounced change in direction should be made on stable material.

Rolling hot bituminous mix is done in the following order:

1. Transverse joints
2. Longitudinal joints (when adjoining a previously placed lane)
3. Breakdown or initial rolling
4. Intermediate or second rolling
5. Finish rolling

As a guide, longitudinal joint and edge rolling should be performed directly behind the paver; breakdown rolling less than 200 feet behind the paver; intermediate rolling 200 feet or more behind the breakdown rolling; and finish rolling as soon as possible behind the breakdown rolling.

Transverse Joints

When a transverse joint is placed next to an adjoining lane, the first pass is made with a steel-wheeled roller moving along the longitudinal joint for a short distance. The surface is then straightedge and corrections made if necessary. The joint is then rolled transversely with all except 6 inches of the wheel width on the previously laid material (fig. 11-49). This operation should be repeated with successive passes covering 6 to 8 inches of fresh material until the entire width of a roll is on the new mix.

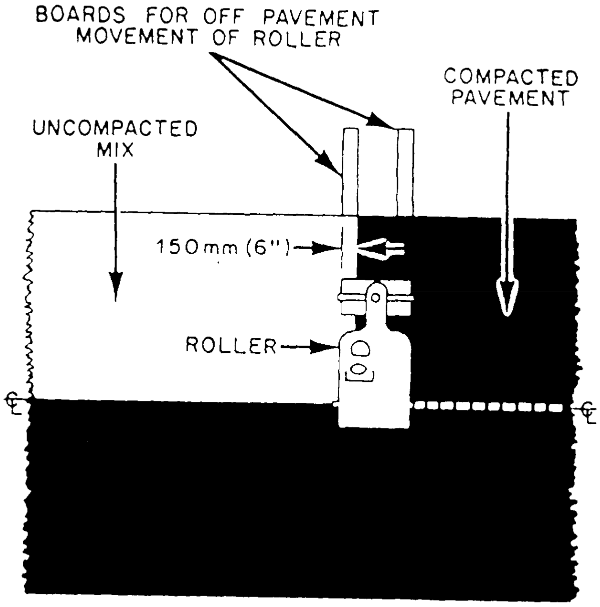


Figure 11-49.-Rolling a transverse joint.

During transverse rolling, boards of proper thickness should be placed at the edge of the pavement to provide the roller a surface to drive on once it passes the edge of the hot bituminous mat. If boards are not used, the transverse rolling must stop 6 to 8 inches short of the outside edge in order to prevent damage to the edge. The outside edge then must be rolled out during longitudinal rolling.

Longitudinal Joints

Longitudinal joints should be rolled directly behind the paving operation, Only 4 to 6 inches of the roller width should ride on the newly placed mix (fig. 11-50). The rest of the roller should ride on the previously compacted side of the joint. With each subsequent pass, more and more of the roller width is placed on the mix until the entire width of the roller is on the newly placed mat.

When rolling a longitudinal joint with a vibratory roller, the roller drum extends only 4 to 6 inches on the previously compacted lane with the rest of the drum width riding on the newly placed mat. The roller continues to roll along this line until a thoroughly compacted, neat joint is obtained.

Longitudinal joints can be categorized as a hot or cold joint.

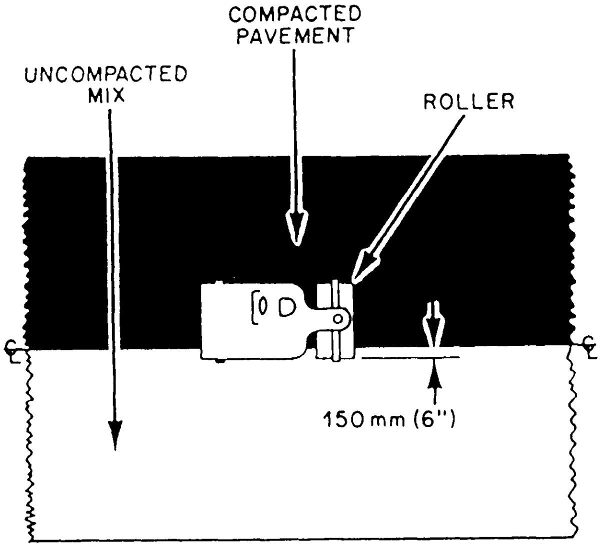


Figure 11-50.—Rolling a longitudinal joint.

HOT JOINTS.— A hot joint is a joint between two lanes of bituminous mix placed at approximately the same time by pavers working in echelon. This type of laydown produces the best longitudinal joint, because both lanes are at, or near, the same temperature when rolled. The material compacts into a single mass under the roller, resulting with little or no difference in density between the two lanes. When you are paving in echelon, the breakdown roller following the lead paver leaves a 3- to 6-inch unrolled edge that the second paver follows. The second paver and roller should stay as close as possible to the first paver to ensure a uniform density is obtained across the joint. The roller following the second paver compacts the hot joint on its first pass (fig. 11-51).

COLD JOINTS.— A cold joint is a joint between two lanes, one of which has cooled overnight or longer before the adjoining lane is placed. Because of the difference in temperature between the two lanes, there is a difference in density between the two sides of the joint. The longitudinal joint should be rolled directly behind the paver.

Breakdown Rolling

Breakdown rolling may be accomplished with static or vibratory steel-wheel rollers. Breakdown rolling should start on the low side of the hot bituminous mat, which is usually the outside of the lane being paved, and progress toward the high side. The reason for this is that hot bituminous mixtures tend to migrate towards the low side of the mat under the action of the roller. If rolling is started on the high side, this migration is much more pronounced than if the rolling progresses from the low side. When adjoining lanes are placed, the same rolling procedure should be followed, but only after compaction of the longitudinal joint.

A rolling pattern that provides the most uniform coverage of the lane being paved should be used. Rollers vary in width, and a single recommended pattern that applies to all rollers is impractical. For this reason, the best rolling pattern for each roller being used should be worked out and followed to obtain the most uniform compaction across the lane.

The rolling pattern not only includes the number of passes but also the location of the first pass, the sequence of succeeding passes, and the overlapping between passes. Rolling speed should not exceed 3 mph. In addition, sharp turns and quick starts or stops are to be avoided.

For thin lifts (a lift of less than 2 inches compacted thickness), a recommended rolling pattern for static

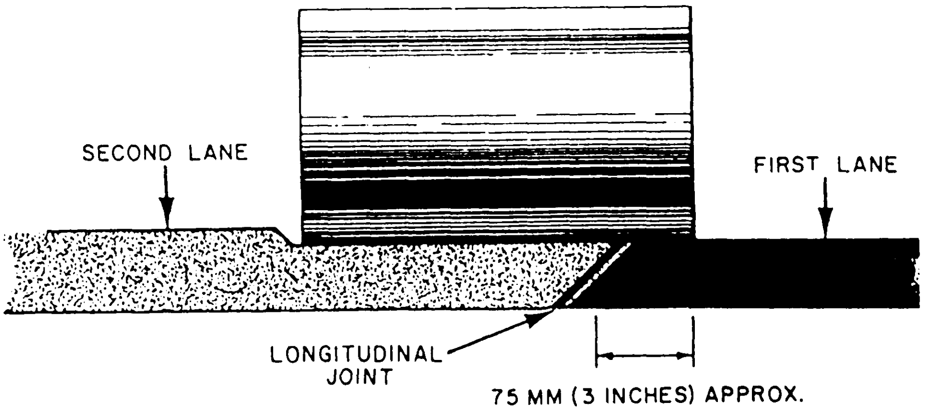
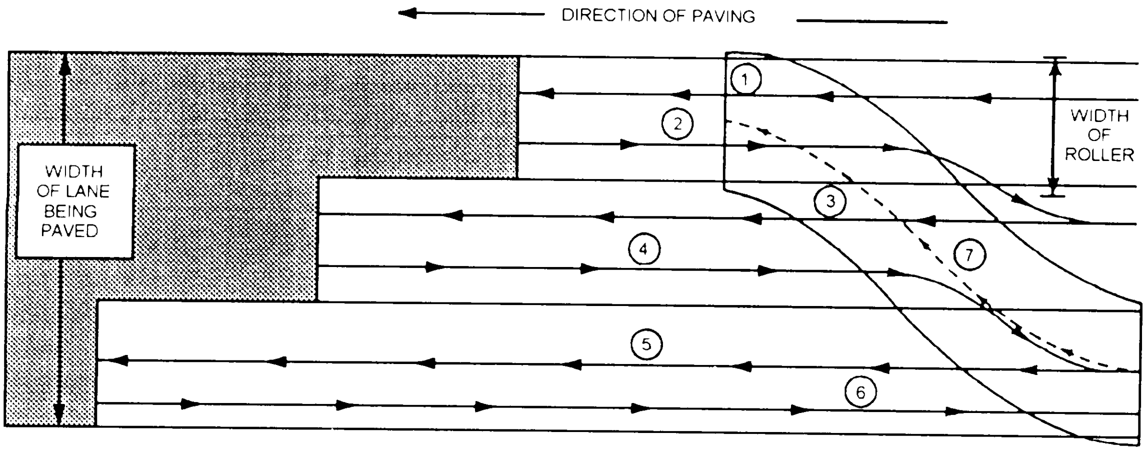


Figure 11-51.—Rolling a hot longitudinal joint.



THIS IS A RECOMMENDED ROLLING PATTERN. EVERY PASS OF THE ROLLER SHOULD PROCEED STRAIGHT INTO THE COMPACTED MIX AND RETURN IN THE SAME PATH. AFTER THE REQUIRED PASSES ARE COMPLETED, THE ROLLER SHOULD MOVE TO THE OUTSIDE OF THE PAVEMENT ON COOLED MATERIAL AND REPEAT THE PROCEDURE.

Figure 11-52.—Correct rolling pattern.

steel-tired rollers is shown in figure 11-52. The rolling operation should start from the edge of the hot mat on the low side with the roller moving forward as close behind the paver as possible. The second movement of the roller should be reversed in the same path until the roller has reached previously compacted material. At this point align the roller for pass number three, again staying as close as possible behind the paver. The fourth movement is a reversal of the third path and a repetition of the third operation. After the entire width of the hot mix has been rolled in this fashion, you should swing the roller back to the low side and repeat the process. With this pattern, on each forward pass the roller only needs to overlap the previous rolled area by 3 to 4 inches.

For thick lifts (a lift of 4 inches or more compacted thickness), the rolling process should start 12 to 15 inches from the lower unsupported edge and progress towards the center portion of the hot mix. The uncompacted edge provides initial confinement during the first pass, thus minimizing lateral movement of the hot mix. After the central portion of the hot mix has been rolled and compacted, the compacted portion of the hot mix will support the roller and allow the edge to be compacted without lateral movement.

When using steel-wheeled rollers, the operation should always progress with the drive wheel forward in the direction of travel. This is especially important in breakdown rolling. A primary reason that breakdown rolling should be done with the drive wheel in the direction of travel is that there is a more direct vertical load applied by this wheel than by the tiller wheel (fig. 11-53).

If the breakdown pass of the roller is made with the tiller wheel forward, the pushing force and the weight arc slightly ahead of the downward vertical force, causing material to push up in front of the wheel. The greater weight of the drive wheel produces the compaction, while the turning force tends to tuck the hot mix under the front of the wheel.

There are exceptions to rolling with the drive wheel forward. They usually occur when superelevations are being constructed or if the grade on which the asphalt mix is being placed is excessive. The exception occurs when, due to these high grades, the drive wheel of the roller begins to chatter on the hot mat, causing displacement of the hot mix resulting with a very rough

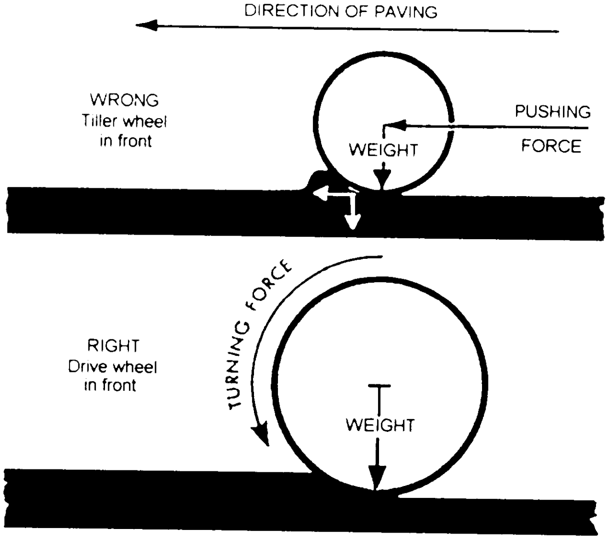


Figure 11-53.—Forces acting when tiller wheel or drive wheel is forward.

surface. In these cases, the roller must be turned around to allow the tiller wheel to compact the material partially so the drive wheel can then proceed over it.

Intermediate Rolling

Intermediate rolling should closely follow breakdown rolling, while the asphalt mix is still well above the minimum temperature of 185 degrees at which densification can be achieved. Pneumatic-tired or vibratory rollers may be used for intermediate rolling. Pneumatic-tired rollers have several advantages:

1. They provide a more uniform degree of compaction than steel-wheeled rollers.

2. They improve the seal near the surface by **kneading** the material closer together.

3. They orient the aggregate particles for greatest stability, as high ground pressure truck tires do after using the asphalt surface for some time.

Tire contact pressures should be as high as possible without causing displacement of the mix that cannot he remedied in the final rolling.

Pneumatic-tired rolling should be continuous after breakdown rolling until all of the hot mix has been thoroughly compacted. At least three coverages should be made.

NOTE: Turning of pneumatic-tired rollers on the hot mix should not be permitted unless it does not cause undue displacement.

Vibratory rollers (of proper static weight, vibration frequency, and amplitude) are used to provide required densities with fewer coverages than static-weight tandem or pneumatic-tired rollers (or combinations of the two).

Regardless of the type of roller used, the rolling pattern should be developed in the same manner as for breakdown rolling. This pattern should be continued until the desired compaction is obtained.

Finish Rolling

Finish rolling is done solely for the improvement of the surface. It should be accomplished with steel-wheel tandems, static-weight or vibratory, while the hot mat is still warm enough for removal of roller marks.

ROLLER SAFETY

Many of the safety precautions previously listed for graders, scrapers, and dozers also apply to roller operations. Additional safety precautions are as follows:

- Never perform roller operations alone. Always have a safety person in the area of the rolling operation.

- Only operate the roller at speeds at which the machine can be kept under control at all times.

- Always wear a scat belt when rolling, as well as other required personal protective equipment, such as steel toe safety shoes and hard hats.

- Operate the roller from the sitting position, never from a standing position.

- Use the safety handrails when mounting or dismounting a roller. Do not grab the transmission control levers, as this might cause the roller to make a sudden movement.

- If the roller ignition starts in any transmission position besides neutral, this machine should be **hardcarded** and repaired before further usage.

- Use caution and make sure the area is clear of personnel, tools, and vehicles when performing forward and reverse rolling operations.

- A roller is easier to overturn than most equipment. Rolling on a side slope should always be done at right angles or diagonally, rather than parallel to the slope.

- Steer carefully when rolling a shoulder to avoid capsizing into the ditch, and never bring a roller near the edge of a cut.

- Use extreme care when loading steel-wheeled rollers on tractor-trailers during periods of inclement weather, The wet deck of the trailer can cause a steel-wheel roller to slip during loading and unloading operations.

CHAPTER 12

CRANES AND ATTACHMENTS

Cranes and attachments are essential to the support of Naval Construction Force (NCF) operations. Lifting heavy objects, loading and unloading construction materials, excavating earthwork materials, and driving and extracting piles are typical tasks accomplished by the use of cranes and attachments.

Cranes and attachments procedures are a complex set of characteristics. Proper and efficient operation of cranes and their attachments requires more knowledge and skill than for any other piece of construction equipment you will operate.

NOTE: You must always be exceptionally safety conscious when working on or around crane operations of any type.

This chapter covers the characteristics and basic principles of operations of cranes and attachments. By reading the operator's manual and attending crane school, you can obtain detailed information about crane operations.

CRANES

Cranes are classified as **weight-handling equipment** and are designed primarily to perform weight-lifting and excavating operations under varied conditions. To make the most efficient use of a crane, you must know their capabilities and limitations.

TYPES OF CRANES

Cranes have evolved from many designs to satisfy the needs of construction and industrial operations. Operational characteristics of all cranes are basically the same. Although the superstructure is about the same on all makes and models of mobile cranes, the carrier, or mounting, may be one of three types: crawler, truck, or wheel (fig. 12-1).

Crawler-Mounted Cranes

The crawler-mounted crane is categorized under the 42-00000 USN number registration series. The crawler-mounted crane is slower and less mobile than the truck-mounted crane; however, the crawler-mount crane provides a stable base for operation of the revolving superstructure.

The travel unit of the crawler crane is shown in figure 12-2. The travel unit includes the base, travel gears, clutches, travel brakes, sprockets, rollers, crawler chains, and crawler treads. The revolving superstructure rotates on the turntable (fig. 12-3).

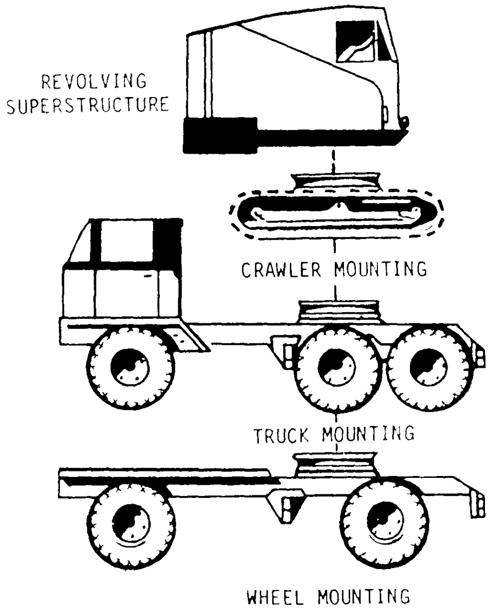

REVOLVING SUPERSTRUCTURE
CRAWLER MOUNTING
TRUCK MOUNTING
WHEEL MOUNTING

Figure 12-1.-Crane carrier mountings.

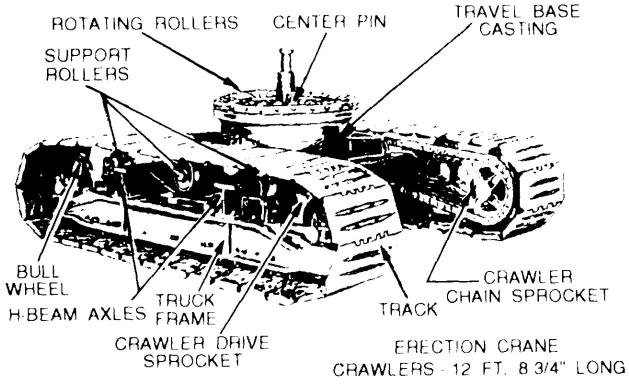

ROTATING ROLLERS
CENTER PIN
TRAVEL BASE CASTING
SUPPORT ROLLERS
BULL WHEEL
H-BEAM AXLES
TRUCK FRAME
CRAWLER DRIVE SPROCKET
TRACK
CRAWLER CHAIN SPROCKET
ERECTION CRANE CRAWLERS - 12 FT. 8 3/4" LONG

Figure 12-2.—Crawler crane travel unit.

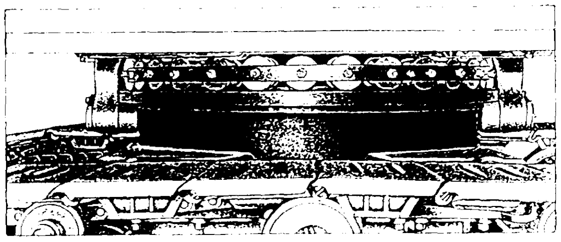
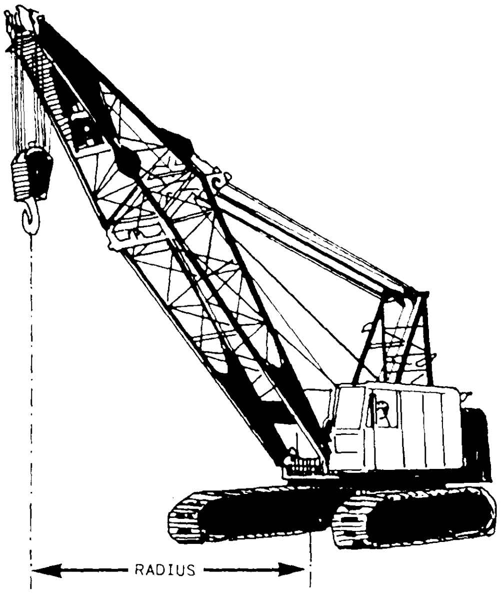


Figure 12-3.—Turntable assembly.



The radius is always measured from the center of rotation and is the radius measured after the boom deflects forward when under load

Figure 12-4.-Crane radius measurement.

The primary advantage of the crawler crane over the truck-mounted crane is that it is better suited for continuous work in remote areas that are not readily accessible to truck-mounted cranes because of terrain conditions. Also, the crawler crane has steering with positive traction that permits the crawler crane to travel and turn without cutting up the work area or roadway.

The size of the crawler treads spreads the weight of the crane over a large area. This feature gives the crawler crane a low ground bearing pressure of 5 to 12 psi, giving the crane the versatility needed to travel over soft terrain. When the crawler crane is climbing grades, the maximum grade capability is 30 percent on firm, dry material. The turning radius of the crawler crane is about the length of the tracks, which travel 1/2 to 2 mph. Because of the slow travel speed, it is not productive to try to travel more than 1 mile. Additionally, traveling the crane a long distance at one time causes extra wear to the tracks. When travel distance exceeds 1 mile, transport the crawler by tractor-trailer.

NOTE: Consult the operator's manual for detailed information if required to track travel for more than 1 mile,

Steering of the crawler crane is performed by engaging the steering lever in the direction you want the crane to turn. Some models of crawler cranes have a swing-travel jaw clutch that is controlled by one lever

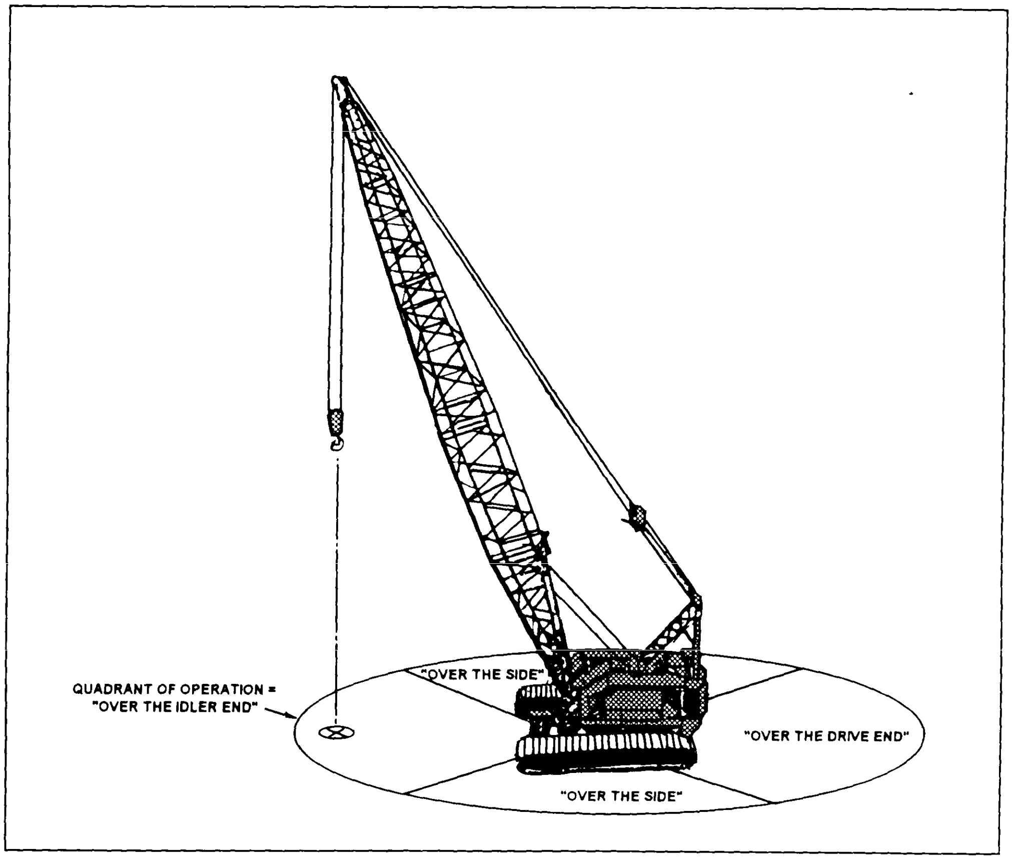


Figure 12-5.—Crawler-mounted crane quadrants of operation.

and provide power for either swinging the crane or traveling the crane. The swing-travel jaw clutch requires the operator to engage a button or push a lever to select for swing or travel operations. Other models have a separate steering and swing lever, allowing both functions to be operated at the same time.

Use caution when traveling with a crawler crane on and around slopes. Some older types of crawler cranes do not have travel brakes and power could be disengaged, causing the crawler to freewheel.

On-the-job maneuvering is easy because of the small turning radius of the crawler crane. Additionally, the crawler crane does not require the use of outriggers for stability, so it requires less room for setting up. On some models of crawler cranes, the tracks can extend outward, providing the crane with more stability. Crawler crane models, on which the crawler tracks can extend, are rated at 85 percent of the minimum weight that can cause the crane to tip at a specified radius with the basic boom, Crawler models that do not have extendable tracks are rated at 75 percent. Crane radius measurement is measured from the center of rotation to the center of the hook after the boom deflects forward when under load, as shown in figure 12-4.

Depending on the make and model, most crawler cranes have a 360-degree working area. This working area is divided into operating areas called **quadrants of operation.** The crane capacity is based on the quadrants, such as for over the side, over the drive end, and over the idler end, for a crawler-mounted crane (fig. 12-5). The capacity of the crane may change when rotating a load from one quadrant to another. This information is provided on the crane load chart.

Truck-Mounted Cranes

The truck-mounted crane (fig. 12-6) consists of a truck carrier and house (upper revolving unit) and is categorized under the 82-00000 USN number registration series. The truck carrier can travel from different jobsites at 20 to 35 mph.

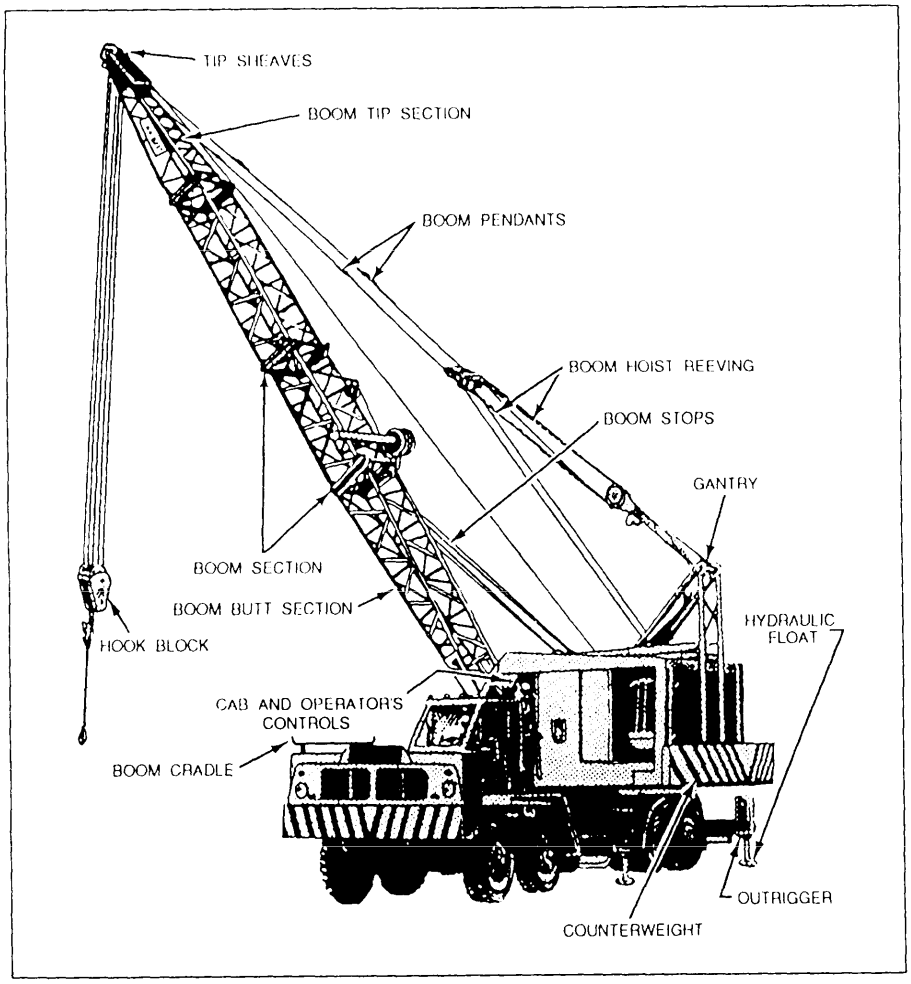


Figure 12-6.—Truck-mounted crane.

Truck cranes have a high ground bearing pressure, ranging from 75 to 100 psi due to the pneumatic tires on which the machine travels. On a firm, dry surface, a truck carrier can climb a 40-percent grade. Depending on the design of the carrier, the turning radius can range from 50 to over 90 feet. This high turning radius limits its maneuverability.

Before any crane travels to a jobsite, the crane crew supervisor must visually review the planned travel route to determine if low wires, low overpasses, narrow bridges, or other unsafe obstacles exist. The absolute limit of approach for power lines (fig. 12-7) is the following:

1. 0 to 125,000 volts, 10 feet
2. 125,000 to 250,000 volts, 15 feet
3. Over 250,000 volts, 25 feet

Anytime you are traveling with a crane, stay a minimum of 4 feet from any electrical power source.

When traveling with a truck-mounted crane equipped with a lattice boom, do NOT rest the boom on the cradle, as the lower cords of the boom can be dented if the boom bounces while traveling. Position the boom 2 to 4 inches above the cradle.

Truck- and wheel-mounted cranes are rated at 85 percent of the minimum weight that can cause the crane to tip at a specified radius with the basic boom. The truck carrier is equipped with outriggers that provide more stability for the crane; therefore, when you are making crane lifts, the outriggers should always be used.

As outlined in the COMSECOND/COMTHIRDNCBINST 11200.1, Naval Mobile Construction

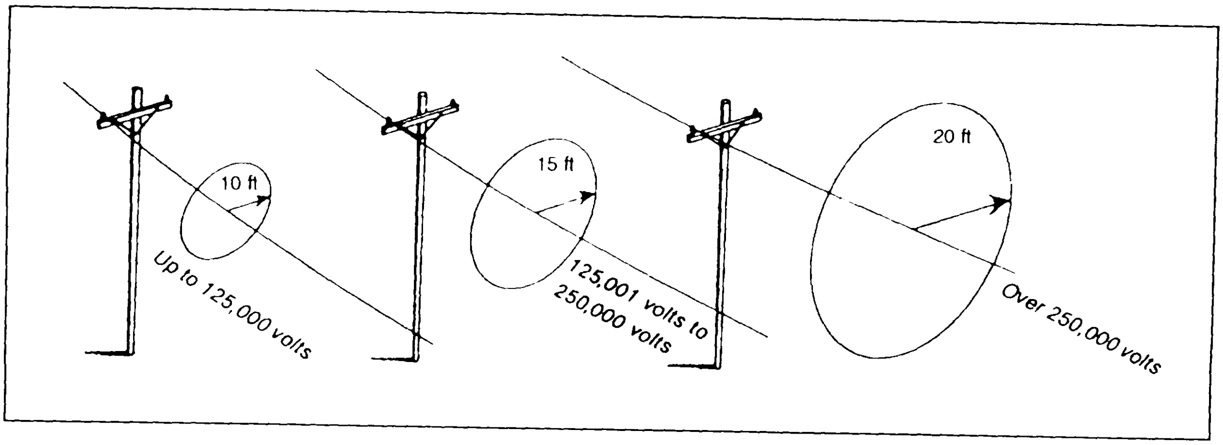


Figure 12-7.—Limit of approach for power lines.

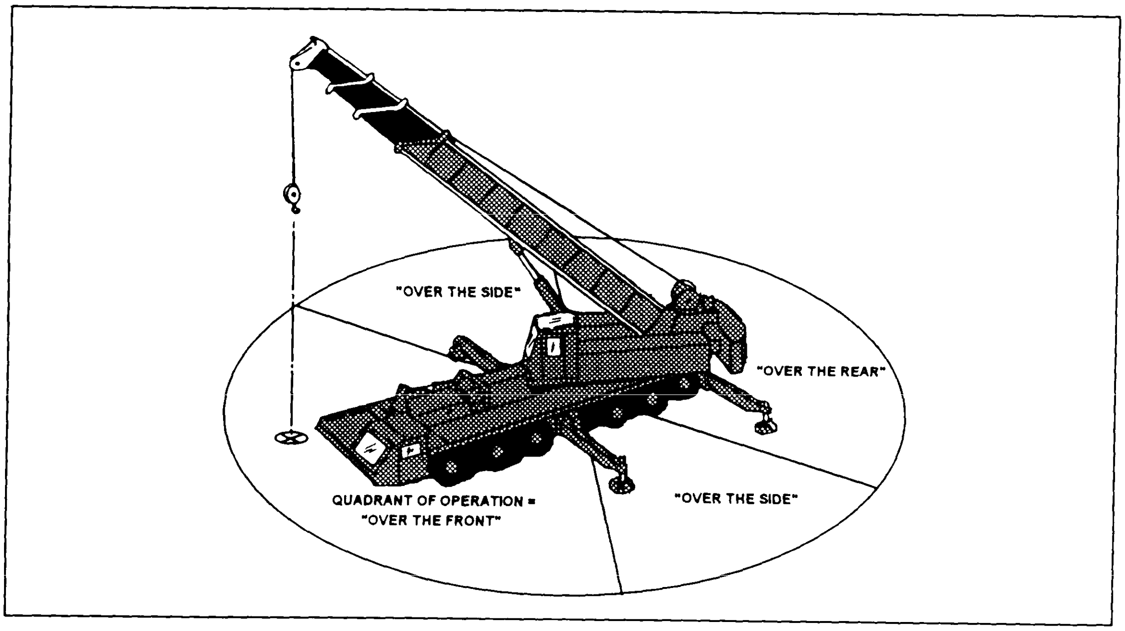


Figure 12-8.—Truck-mounted crane quadrants of operation.

Battalion, Equipment Management, rated free loads or pick and carry operations will only be performed according to NAVFAC P-307 during a crane certification, in case of an emergency, or as directed by the crane certifying officer.

Depending on the make and model, most truck-mounted cranes have a 270-degree working area. Some truck-mounted cranes are equipped with an optional front outrigger that provides a 360- degree working area The quadrants of operation for truck-mounted crones are over the side, over the rear, and over the front if equipped with the front outrigger (fig. 12-8).

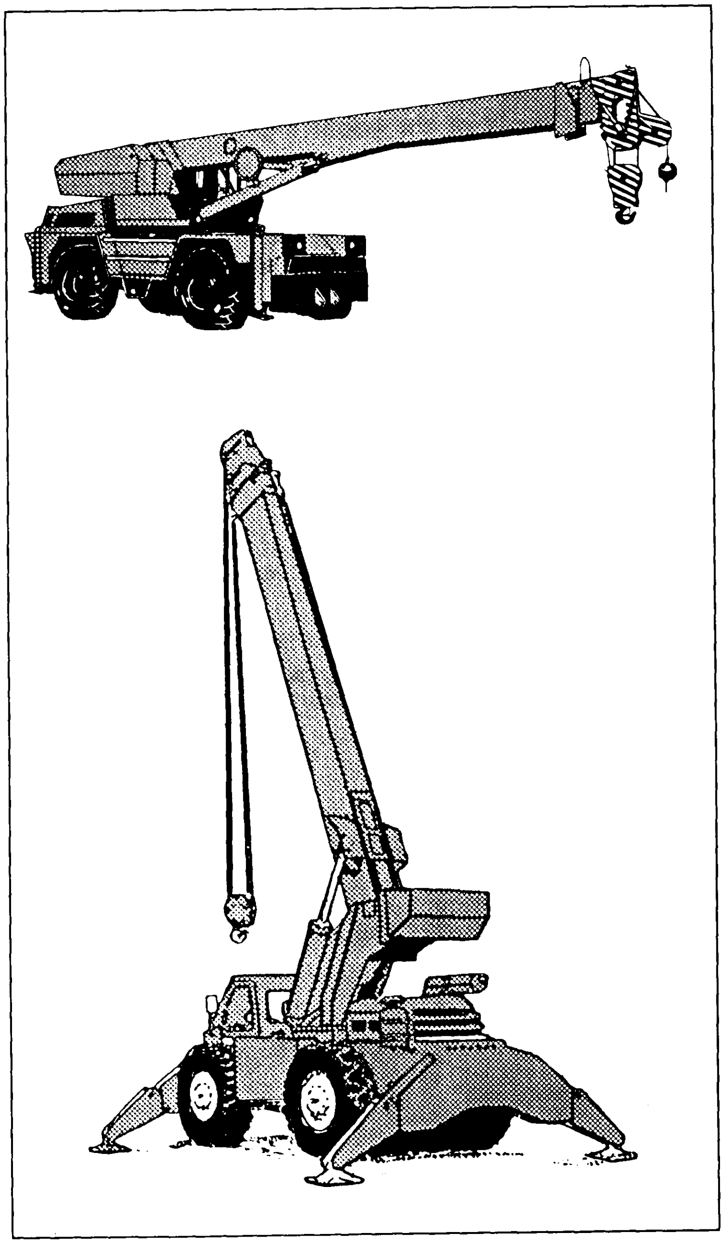


Figure 12-9.—Wheel-mounted cranes.

NOTE: The capacity of the crane may change when rotating a load from one quadrant to another. This information is provided on the crane load chart.

Wheel-Mounted Cranes

Wheel-mounted cranes range in various sizes and have capacities from 5 to 35 tons or larger (fig. 12-9).

The wheel-mounted cranes shown in figure 12-9 are hydraulically operated, four-wheel drive, four-wheel steer, pneumatic-tired, engine-powered diesel. The superstructure consists of a telescoping boom, single-acting hydraulic lift cylinders, a hydraulically operated hoist drum, and a hook block attachment.

The wheel-mounted crane has a ground bearing pressure of about 35 psi and can travel at speeds ranging from 2 to 30 mph. It can turn in a 30-foot radius with two-wheel steering and in a 17-foot radius with four-wheel steering and can travel up a firm, dry 40-percent grade.

The wheel-mounted crane is a mobile and flexible crane that can be driven on or off roads over rough terrain. It is best suited for lifts around shops or for supporting fabrication projects that call for many varied, mobile lifts within a small working area.

Depending on the make and model, most wheel-mounted cranes have a 360-degree work area The quadrants of operation for wheel-mounted cranes are over the side, over the rear, and over the front (fig. 12-10). **Remember** that the capacity of the crane may

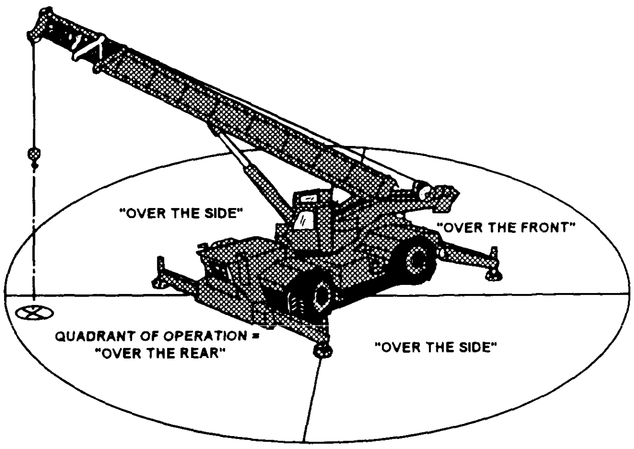


Figure 12-10.—Wheel-mounted crane quadrants of operation.

change when rotating a load from one quadrant to another. This information is provided on the crane load chart.

LATTICE BOOM CRANE

The major components of a lattice boom crane are shown in figure 12-11. Inspecting each of these components is part of the operator's prestart inspection.

The lattice boom supports the working load and is the most common boom used in the NCF. It is used on all types and makes of cranes and is mounted at the boom butt on the revolving superstructure. The basic boom consists of the boom butt and boom tip, and the length is increased by adding boom extensions.

Boom Sections

Lattice boom sections are made of lightweight, thin wall, high strength alloy tubular or angle steel and are designed to take compression loads. The most common boom is tubular. Terminology of a lattice boom section is shown in figure 12-12.

Manufacturers have set a zero tolerance on rust, bent lacings or cords, cracked welds, and other problems that affect the strength of the lattice boom. This zero tolerance requires crane crews to use extreme care when handling unused sections with forklifts, storing unused sections away from traffic areas, transporting and securing sections on tractor-trailers, and preventing equipment or obstacles from running into the boom while mounted on the crane during transport, performing operations, or when parked.

As outlined in the *Management of Weight-Handling Equipment, Maintenance and Certification,* NAVFAC P-307, all lattice boom cranes with structural damage to the main cords of the boom must be immediately

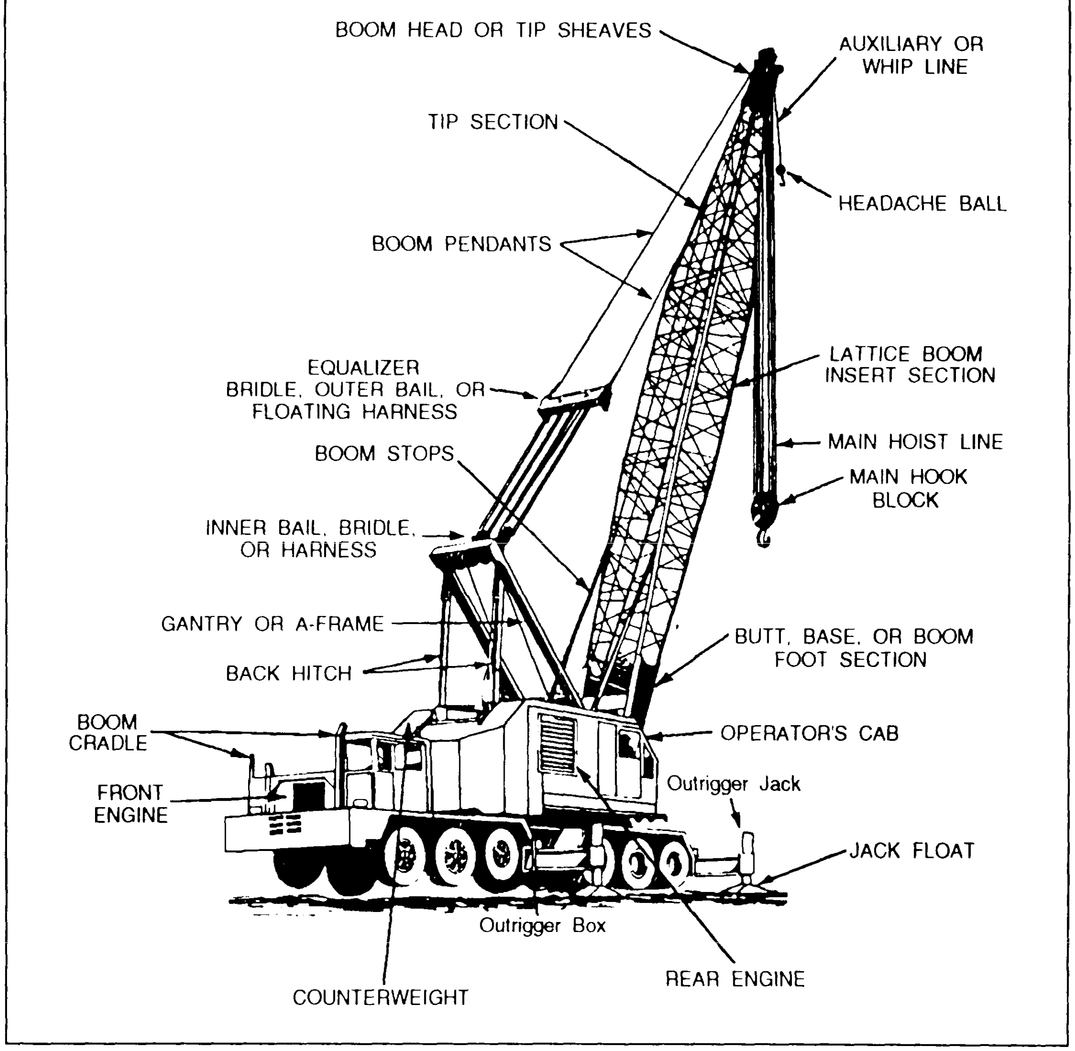
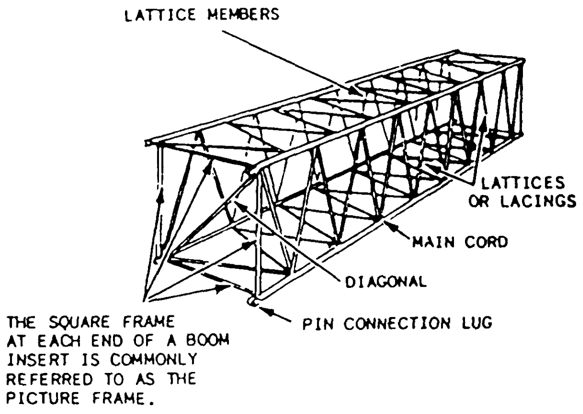

BOOM HEAD OR TIP SHEAVES
AUXILIARY OR WHIP LINE
TIP SECTION
HEADACHE BALL
BOOM PENDANTS
EQUALIZER BRIDLE, OUTER BAIL, OR FLOATING HARNESS
LATTICE BOOM INSERT SECTION
MAIN HOIST LINE
BOOM STOPS
MAIN HOOK BLOCK
INNER BAIL, BRIDLE, OR HARNESS
GANTRY OR A-FRAME
BUTT, BASE, OR BOOM FOOT SECTION
BACK HITCH
BOOM CRADLE
OPERATOR'S CAB
FRONT ENGINE
Outrigger Jack
JACK FLOAT
Outrigger Box
REAR ENGINE
COUNTERWEIGHT

Figure 12-11.—Lattice boom crane components.


LATTICE MEMBERS
LATTICES OR LACINGS
MAIN CORD
DIAGONAL
PIN CONNECTION LUG
THE SQUARE FRAME AT EACH END OF A BOOM INSERT IS COMMONLY REFERRED TO AS THE PICTURE FRAME.

33Figure 12-12.-Lattice boom terminology.

removed from service. When the main cords of tubular boom sections are damaged in any manner, including slight dents, they are severely weakened and have failed at loads significantly below capacities. As outlined in the 11200.1, structural repairs will not be made without written approval from COMSECOND/COMTHIRDNCB equipo offices.

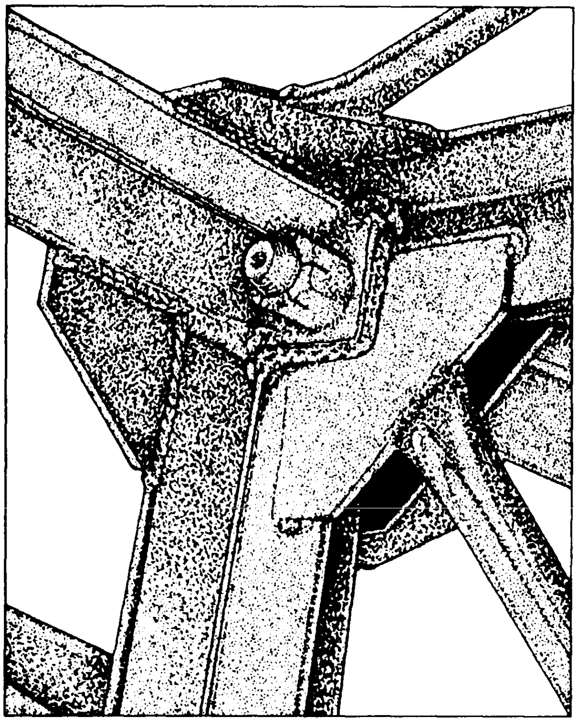
In the NCF, sections normally come in 10- to 20-foot lengths. When adding several sections of different lengths, check the operator's manual for boom section configuration. If this information is not in the operator's manual, a rule of thumb used when mixing short boom sections with long sections, you install the shorter sections closest to the boom butt; for example, if you use two 10-foot sections and one 20-foot section, install the two 10-foot sections closest to the boom butt. The boom sections are bolted by plate (flange) connections (fig. 12-13, view A) or pin and clevis connections (fig. 12-13, view B). The most common is the pin and clevis.

All boom sections that come with a crane will have an attachment identification number attached that assigns the boom section to a specific crane.

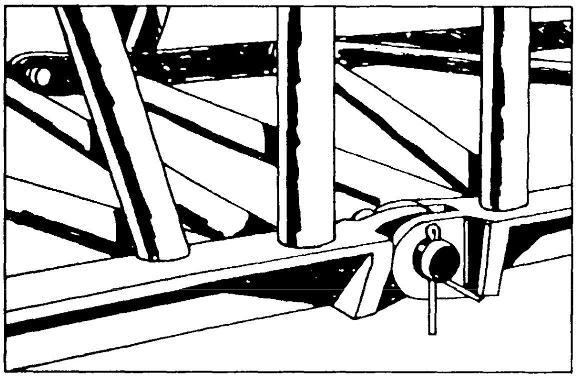
Boom Angle Indicators

Boom angle indicators are normally mounted on the boom butt, visually readable by the operator. On most models in the NCF, the boom angle indicator is a metal plate with degree numbers (0 to 90 degrees) and a freely swinging arm that reacts as the boom angle changes (fig. 12-14). The numbers and arm should remain clean and visually readable at all time.

The capacities that are listed on the crane load charts are also based on and vary with the boom angle of the crane. On hydraulic cranes, the boom angle is the angle between the bottom of the boom butt and the horizontal



VIEW A
BOLT CONNECTION



VIEW B
PIN CONNECTION

Figure 12-13.—Boom sections connection.

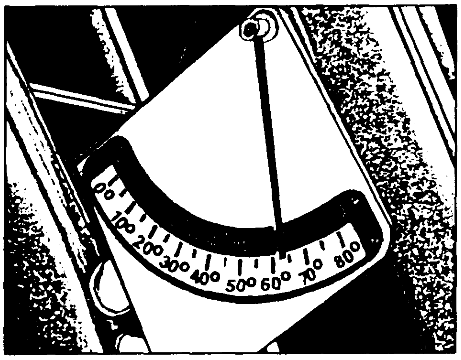


Figure 12-14.—Boom angle indicator.

while the boom is under load (fig. 12-15, view A). The boom angle on lattice boom cranes is the angle between the center line of the boom (from the boom butt pins to the boom tip sheave) and the horizontal while the boom is under load (fig. 12-15, view B).

To check the accuracy of the boom angle indicator, place a 3-foot builders level on the center boom section and raise or lower the boom until the level indicates the boom is level (fig. 12-16). At this point the boom angle indicator

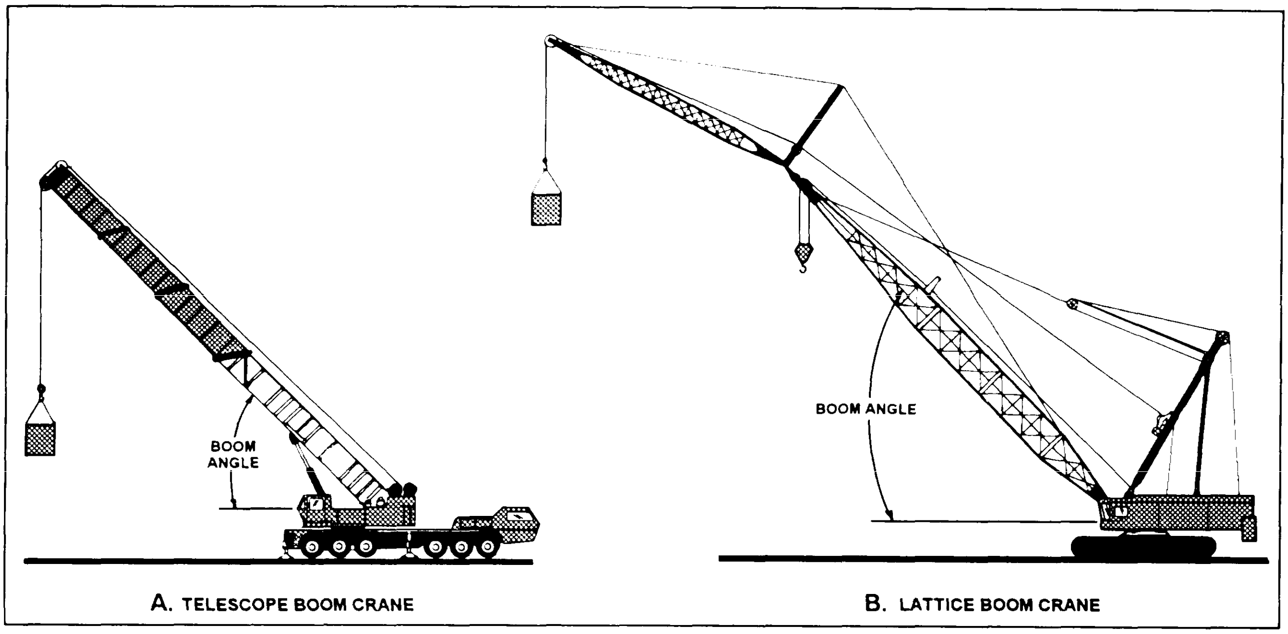

BOOM ANGLE
A. TELESCOPE BOOM CRANE
BOOM ANGLE
B. LATTICE BOOM CRANE

Figure 12-15.—Boom angle configurations.

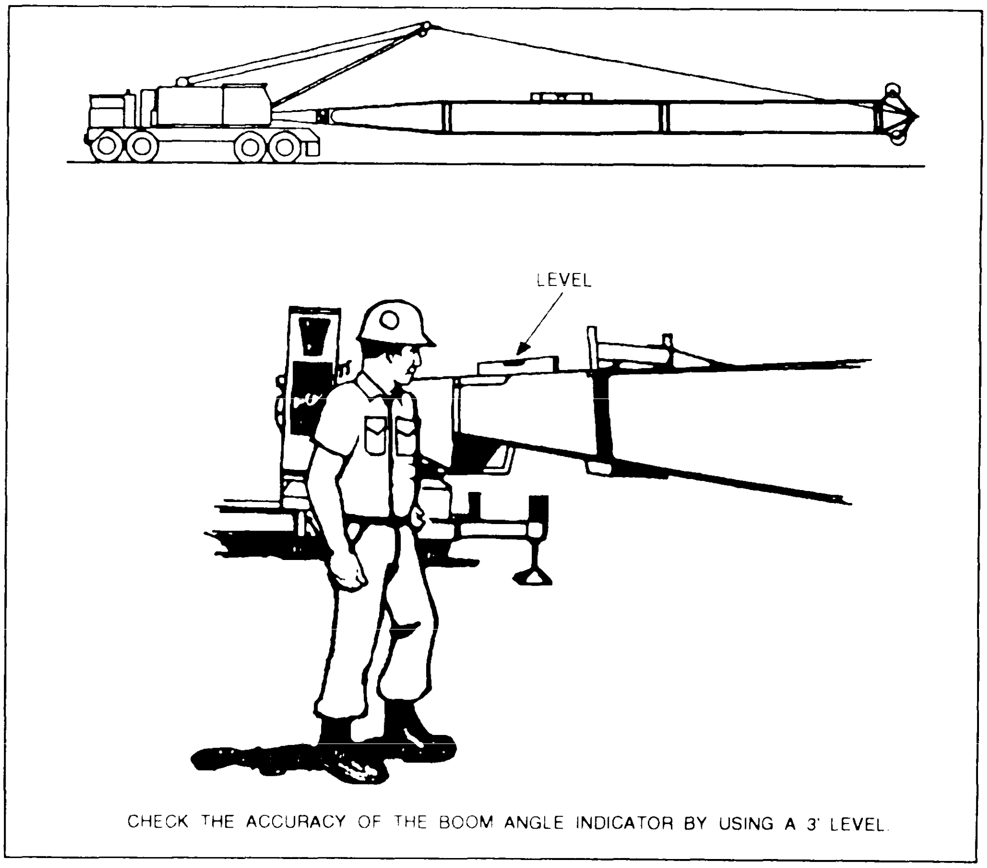

LEVEL
CHECK THE ACCURACY OF THE BOOM ANGLE INDICATOR BY USING A 3' LEVEL.

Figure 12-16.-Check accuracy of boom angle indicator.

should show the boom is at zero degrees or adjusted to read zero degrees.

The boom angle indicator is a quick reference for the operator to know what angle the boom is at. However, do NOT rely on the boom angle indicator for radius accuracy especially when the lift exceeds 75 percent of the rated capacity. Use the radius measurement to determine the capacity of the crane from the load charts and to avoid any possibility of error.

Sheaves

Sheaves are located in the hook block boom tip, boom bridle, gantry, and boom mast. Sheaves rotate on either bearings, or bushings, and are installed basically anywhere wire rope must turn or bend.

Boom Pendants

A pendant line is a fixed-length of wire rope, forming part of the boom suspension system. Each section of boom has two boom pendants. Both pendants must stay with the section of the boom they came with. When storing a boom section, secure the two pendants to the boom section with tie wire or rope. If a pendant is bad, both pendants must be replaced. If you only replace the one bad pendant, the new or replaced pendant could be of a different length or be different in manufacture. This difference will cause an uneven pull or twist on the boom when the boom is put under a load or strain.

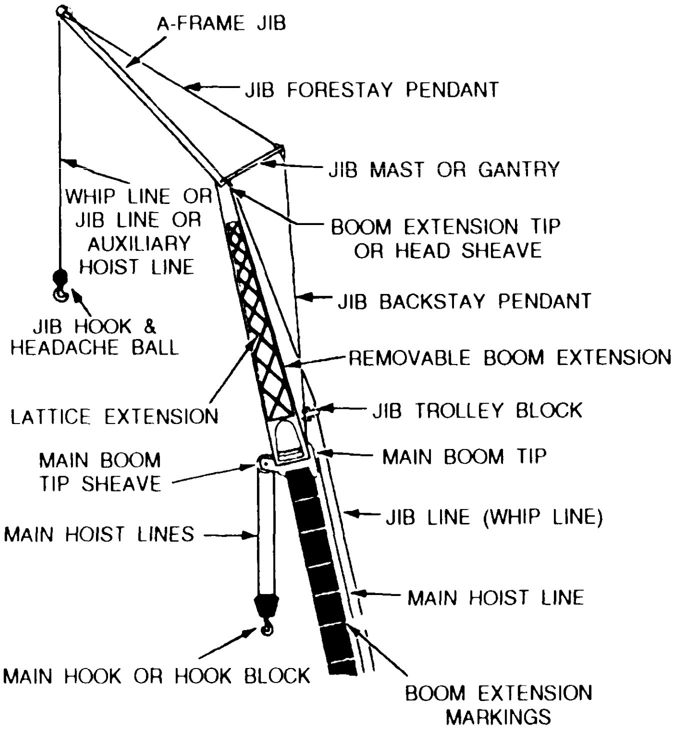

A-FRAME JIB
JIB FORESTAY PENDANT
JIB MAST OR GANTRY
WHIP LINE OR JIB LINE OR AUXILIARY HOIST LINE
BOOM EXTENSION TIP OR HEAD SHEAVE
JIB BACKSTAY PENDANT
JIB HOOK & HEADACHE BALL
REMOVABLE BOOM EXTENSION
LATTICE EXTENSION
JIB TROLLEY BLOCK
MAIN BOOM TIP SHEAVE
MAIN BOOM TIP
JIB LINE (WHIP LINE)
MAIN HOIST LINES
MAIN HOIST LINE
MAIN HOOK OR HOOK BLOCK
BOOM EXTENSION MARKINGS

Figure 12-17.—Jib and boom extension mounted on a hydraulic boom.

Jib and Extension

Figure 12-17 shows one type of jib and boom extension. A jib is an extension of a boom capable of being mounted on either a hydraulic or lattice boom. The jib is equipped with its own forestay pendant lines, connected from the jib tip to the jib mast. The jib mast is connected to the boom tip. The jib backstay pendant is normally manually adjustable to change the angle of the jib.

On most cranes the function of the jib is to increase the lift height and to aid in increasing load radius. The operator's manual will have instructions on how to install a jib or extension. You must remember if lifts are made with the main hook block the weight of the jib assembly will reduce the lifting capacity of the crane; therefore, you must deduct the effective weight of the jib assembly from the gross capacity of the crane.

Gantry

The gantry, or A-frame, is a structural frame, extending above the revolving superstructure (fig. 12-18). The gantry supports the sheaves in which the

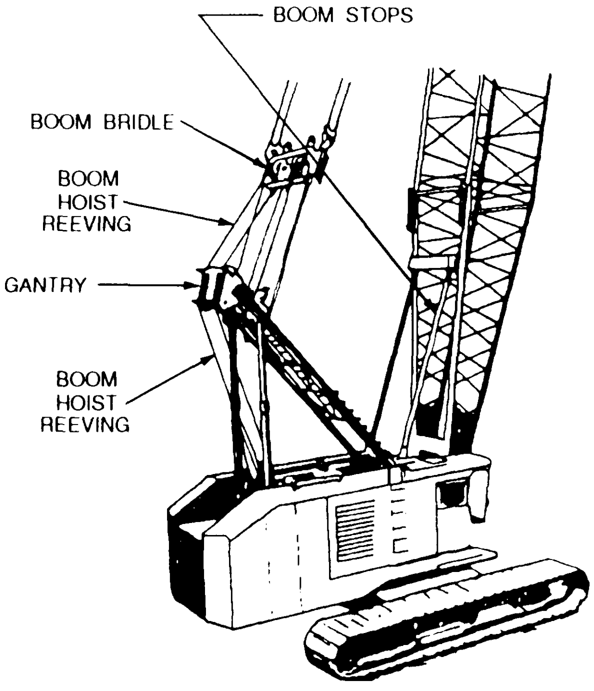

BOOM STOPS
BOOM BRIDLE
BOOM HOIST REEVING
GANTRY
BOOM HOIST REEVING

Figure 12-18.-Gantry.

boom hoist lines are reeved. The height of the gantry provides an angle between the boom pendant lines and boom that reduces the compression forces placed on the boom during raising and lifting operations. On some models of cranes, the gantry is adjustable, allowing it to be lowered so the crane can travel under wires and bridges.

WARNING

Refer to the operator's manual for instructions on how to raise and lower the gantry. A trial-and-error method of lowering or raising the gantry can cause serious injury or death.

NOTE: Raising the boom while the gantry is in the lowered position lowers the angle between the pendants lines and boom. This places unseen compression stresses on the boom; therefore, always raise the gantry before raising the boom or lifting a load.

Boom Mast

Some models of cranes are equipped with a boom mast instead of a gantry. The boom mast, sometimes called live **mast,** consists of a structural frame hinged at or near the bottom of the boom butt (fig. 12-19). The tip of the boom mast supports the boom hoist sheaves and boom pendant lines. The boom mast works like the gantry, as it increases the angle between the boom pendants and boom, decreasing the compression forces placed on the boom.

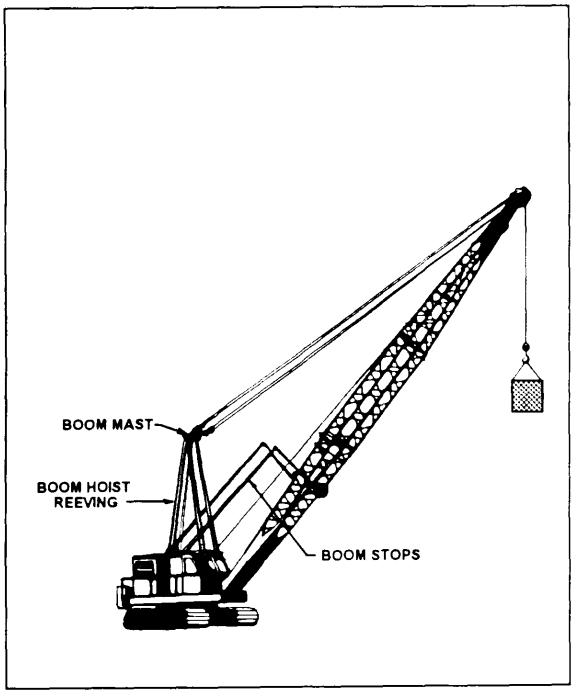


Figure 12-19.—Boom mast.

Bridle Assembly

The bridle assembly is part of the boom suspension system and is sometimes called a floating harness. The bridle assembly may be connected to the boom mast or as a floating harness on a crane equipped with a gantry. The bridle assembly is the connection point for the boom pendant lines and is an assembly of sheaves in which the boom hoist wire rope reeves through.

Boom Stops

Boom stops are designed to prevent the boom from going over backwards in case a load line breaks. They will not stop the boom if the operator forgets to disengage the boom hoist control lever. However, some models of cranes are equipped with a boom upper limit switch that prevents the operator from raising the boom past a preset boom angle. This switch also prevents operators from raising the boom into the boom stops. Most cranes that are equipped with the upper limit switch also have a bypass switch that allows the operator to raise the boom past the preset boom angle. Two types of boom stops are shown in figures 12-18 and 12-19.

House Assembly

The house assembly is a revolving superstructure that sets on top of the carrier frame (fig. 12-20). It provides a mount for the hoist mechanisms and engine and is sometimes called the **machinery deck.** The operator's cab and counterweight are attached to the home assembly.

OPERATOR'S CAB.— The control levers for a lattice boom crane are located in the operator's cab. The control levers that are shown in figure 12-21 are typical of most cranes.

Typical crane controls areas follows:

1. The swing lever, when pulled towards you, rotates the house assembly in one direction, and when pushed, the house assembly rotates in the opposite direction.

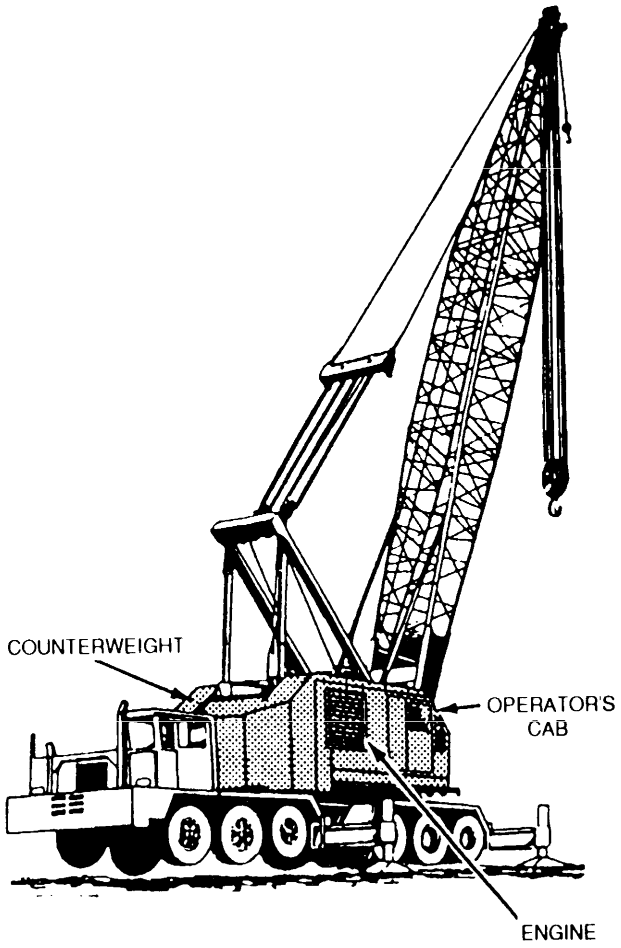


Figure 12-20.—House assembly.

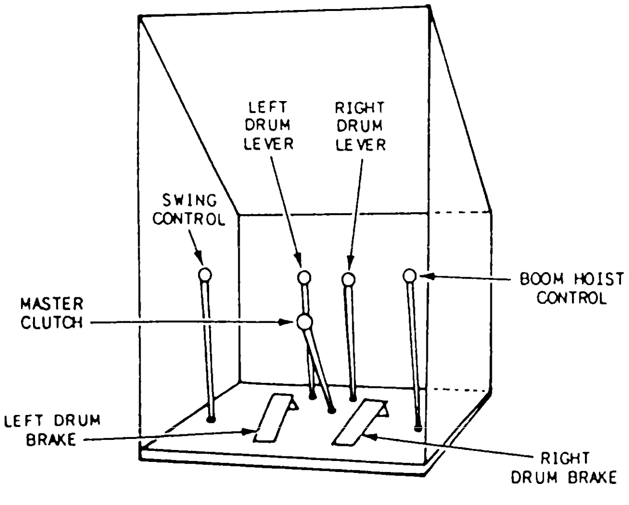


Figure 12-21.—Lattice boom crane control levers.

2. The left drum brake pedal is used to hold and lower loads placed on the hoist line. When locked, it prevents the hook block and wire rope from unwinding on the hoist drum. Figure 12-22 shows a typical hoist brake assembly.

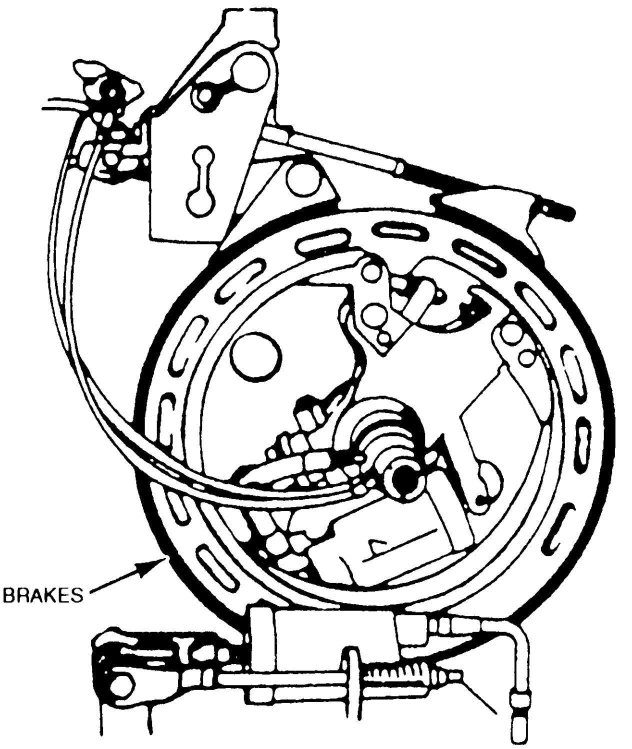


Figure 12-22.—Hoist brake assembly.

3. The main drum lever engages power to raise and, on some models, support lowering of loads placed on the main hoist drum.

4. The master clutch engages the power from the power source to the hoist and swing mechanisms.

5. The secondary drum lever engages power to raise and, on some models, support lowering of loads placed on the secondary hoist drum.

6. The right drum brake pedal is used to hold and lower loads placed on the hoist line. When locked, it prevents the hook block and wire rope from unwinding on the hoist drum.

7. The boom hoist lever allows for the raising and lowering of the boom.

HOISTING MECHANISM.— The hoisting mechanism provides the mechanical power to lift and lower loads. The hoisting mechanism usually has two hoist drums that are mounted side by side on one shaft or in tandem. A separate clutch and brake controls each hoist. The control levers, operating the clutches and brakes, are normally power-assisted with hydraulics or air pressure. A lifting operation requires the use of one drum; whereas the clamshell, dragline, and pile-driving operations require the use of two.

ENGINE.— The engine provides power to the hoisting mechanism through a gearbox or, in some cases, a drive chain reduction. In most lattice boom cranes, the engine is mounted in the crane house.

COUNTERWEIGHT.— The counterweight on the rear of the crane house creates additional stability when lifting loads. The counterweight rotates with the house as it swings. Most counterweights are removable to reduce the overall weight of the crane for transporting. Part of your prestart inspection is to check the counterweight mounting.

Lattice Boom Breakdown

The bridle assembly plays an important part when changing the length of the boom. If you forget to disconnect the boom pendants lines from the boom tip, and not connect the bridle assembly or pendant lines behind the boom section you plan to remove or install, and you drive out the bottom pins, the top pins will act as a hinge and the boom will fall, as shown in figure 12-23. If you make this mistake and a crew member is under the boom, a tragedy could result, as shown in figure 12-24.

WARNING

> **NEVER WORK UNDER A CRANE BOOM.** Because so many accidents have occurred while personnel were changing booms, some manufacturers have made a one-way connecting pin that can only be installed from the inside. This requires the pin to be removed only from the outside, keeping personnel from getting underneath the boom (fig. 12-25). A common practice in the NCF is to install the pins from the inside out to prevent personnel from maneuvering inside the boom to drive out the pins.

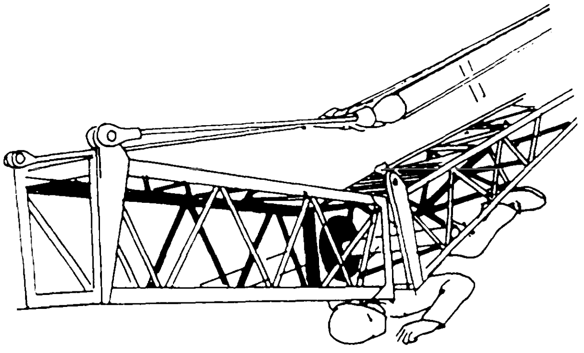


Figure 12-24.-Never work under a crane boom.

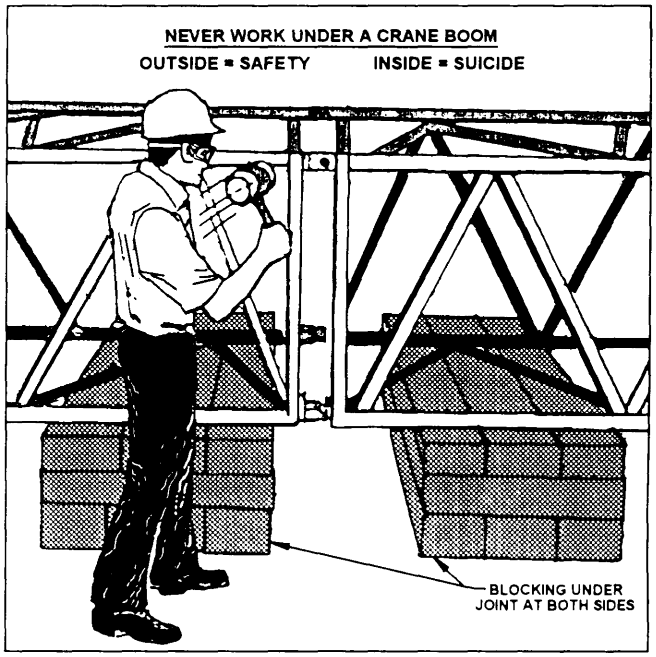

NEVER WORK UNDER A CRANE BOOM
OUTSIDE = SAFETY
INSIDE = SUICIDE
BLOCKING UNDER JOINT AT BOTH SIDES

Figure 12-25.-Drive pins from the outside in.

Several methods are used to break down lattice booms to add or take out sections. If the boom sections are bolt-connected, you must use dunnage for support under each section.

The most common boom connection is with pins. To break down a pin-connected boom, make sure you

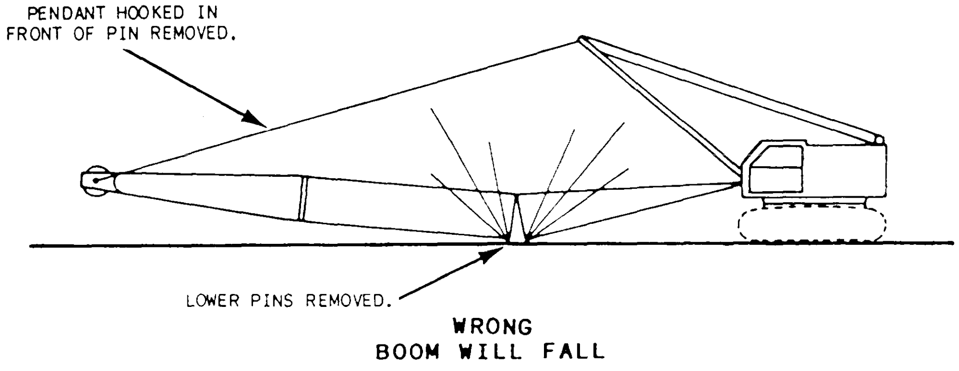


Figure 12-23.—Incorrect way to disconnect the lattice boom.

have gloves, hardhats, safety glasses or goggles, and safety shoes for all hands, sledge hammers, pliers, crowbars, marlin spikes, extra cotter pins, and dunnage.

WARNING

Always wear gloves when handling wire rope.

NOTE: When breaking down a lattice boom, take the opportunity this provides to inspect items thoroughly, such as the connecting pins, cotter keys, and inside the connecting lugs for wear, rust, and surface cracks.

A common method used to break down a pin-connected basic boom and add a section is as follows:

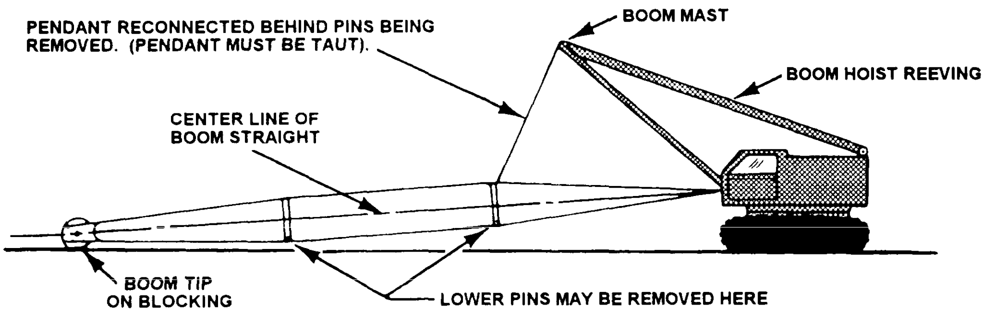
1. Set outriggers and swing the upper revolving unit over the rear or side, depending on the make and model of the crane.

2. Lower the hook block(s) to the ground and provide slack in the hoist line(s). Next, lower the boom and set the boom tip sheaves on a piece of dunnage.

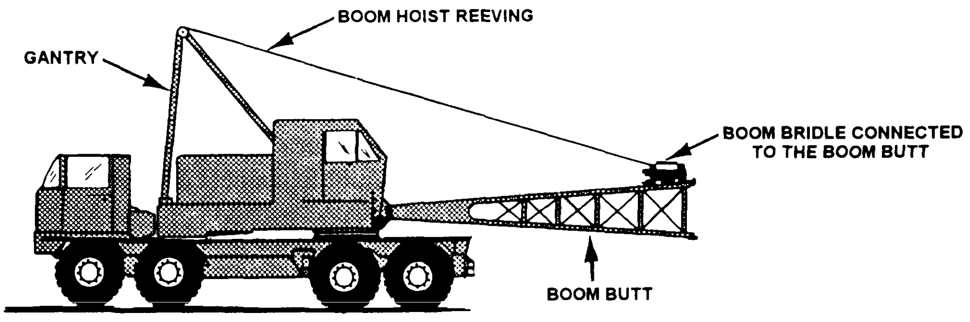
3. Engage the boom hoist control lever to lower the bridle assembly or boom mast to slacken the pendant lines.

4. To prevent the pendant lines from falling on the ground, use tie wire or rope to secure the pendant lines to the boom. Then remove the cotter pins and drive out the main pins from the bridle assembly connections in the pendant lines.

5. Position the bridle assembly on top of the boom butt (fig. 12-26, view A). This is done by having the operator engage the boom hoist control lever to tighten the boom hoist lines until the bridle is positioned on top of the boom butt. To align the pinholes, manually position the bridle assembly using the crowbar. The pins that are used for the pendant line connections are


PENDANT RECONNECTED BEHIND PINS BEING REMOVED. (PENDANT MUST BE TAUT).
BOOM MAST
BOOM HOIST REEVING
CENTER LINE OF BOOM STRAIGHT
BOOM TIP ON BLOCKING
LOWER PINS MAY BE REMOVED HERE

A. BOOM MAST CONNECTION


BOOM HOIST REEVING
GANTRY
BOOM BRIDLE CONNECTED TO THE BOOM BUTT
BOOM BUTT

B. BOOM BRIDLE CONNECTION

Figure 12-26.-Boom hoist assembly connected to boom butt.

normally the pins used to connect the bridle assembly to the boom butt. If the crane is equipped with a boom mast, the boom mast normally has a short set of pendants that connect to the boom butt pinholes (fig. 12-26, view B).

NOTE: Visually check the boom hoist drum to ensure the boom hoist wire rope does not loosen and cross wind on the hoist drum, resulting in crushing or kinking the wire rope.

6. Tighten the boom hoist lines to support the weight of the boom, but not so tight that the boom tip is lifted off the dunnage.

7. Remove the cotter pins from the boom connection pins and drive out the lower boom connection pins.

8. After the lower pins are removed, engage the boom hoist control lever and lower the bridle assembly or mast, allowing the boom to separate at the bottom by hinging on the top pins. hen lower the boom on a piece of dunnage.

9. Remove the top connecting pins. Once removed, engage the boom hoist enough to separate the boom connections lugs.

When the boom breakdown is performed over the rear of the crane, you separate the boom by (1) raising the outriggers enough to move forward with the travel unit and by (2) releasing the brakes on the hoist line(s) to slacken the hoist wire rope, as the travel unit moves forward to allow space to add a section(s).

When the boom breakdown is performed over the side of the crane, you separate the boom by (1) releasing the brakes on the hoist line(s) to slacken the hoist wire rope and by (2) using a forklift to pick up the boom tip carefully and maneuver it enough to provide adequate space to insert a boom section(s).

A method for adding a boom section is as follows:

1. Have a forklift align the boom section with the boom butt.

2. Reverse the crane until the boom butt top pin connection lugs are connected with the top pin connection lugs on the boom section. The boom breakdown performed over the side requires a forklift to maneuver the boom section until the pins are aligned.

3. Once the top lugs are aligned, drive the boom connection pins into the top lugs from the inside out and insert the cotter pins.

4. Engage the boom hoist control lever to raise the boom butt. This allows the top pins to perform as a hinge that draws the bottom pin connection lugs together.

5. Once the bottom lugs are aligned, drive the boom connection pins into the bottom lugs from the inside out and insert the cotter pins.

6. Raise the boom butt and boom section several inches to clear the ground. Reverse the crane until the top connection lugs of the boom section align with the top connection lugs of the boom tip. Final alignment of the lugs might require the use of a crowbar.

7. Once the lugs are aligned, drive the boom connection pins into the top lugs and insert the cotter pins.

8. Engage the boom hoist control lever to raise the boom section and boom tip. This results with the top pins performing as a hinge, drawing the bottom pin connection lugs together.

9. Once the bottom lugs are aligned, drive the boom connection pins into the bottom lugs from the inside out and insert the cotter pins.

10. Reset the outriggers.

The procedures for connecting the bridle assembly to the boom pendants are as follows:

1. Engage the boom hoist control lever to lower the bridle assembly or boom mast to produce slack in the boom hoist wire rope.

2. The next step is to connect the boom bridle assembly to the boom section pendant lines. This is done by disconnecting the bridle assembly from the boom butt and manually maneuvering the bridle assembly to connect with the boom pendants of the boom section. To produce slack in the bridle assembly may require manually feeding of the boom hoist wire rope through the sheaves.

For cranes equipped with a boom mast, lower the boom mast to connect the pendant lines.

3. When the pendants are connected to the bridle, it is a good practice to insert the pins from the inside out. This practice allows for a easier visual inspection of the cotter pins inserted in the pendant line pins when the boom is in the air.

4. The next step is to connect the boom section pendants to the boom tip pendants. This usually requires manual labor to align the boom section pendants to the boom tip pendants. You may also have to engage the boom

hoist control lever to provide slack in the boom hoist lines to align the pendant lines. Once the pendants are aligned, insert the pendant connection pins and cotter pins.

5. Next, engage the boom hoist control lever to raise the bridle assembly and pendants. Before doing this, go back through and visually inspect all boom and pendant line pin connections and cotter pins. Have someone visually watch the boom hoist drum to ensure the wire rope does not cross wind, causing the wire rope to be crushed or kinked. Additionally, ensure all of the boom hoist wire rope is properly running on all of the sheaves. Once everything checks out, engage the boom hoist control lever and raise the bridle assembly and pendants until they are tight.

6. Visually check the boom suspension system before raising the boom off the ground As the boom is being raised, visually check the reeving of the boom hoist wire rope.

7. Once the boom is erected, check the hoist wire rope reeving. You want to ensure the wire rope is correctly flowing through the boom tip and hook block sheaves and winding properly on the hoist drum.

Before the crane can be operated, as outlined in the *NMCB, Equipment Management*, COMSECOND/ COMTHIRDNCBINST 11200.1, and before putting the crane back in service, the crane test director must inspect the crane for correct installation of all components and verify the prior testing and mechanical condition of added components. The crane certifying officer may direct the crane to be load-tested at its safe load capacity at minimum and maximum radius.

TELESCOPIC BOOM CRANES

Telescopic boom cranes are typically called hydraulic cranes. The booms are composed of a series of rectangular, trapezoidal, or other shape of symmetrically cross-sectional segments, fitting into each other. The largest segment, at the bottom of the boom, is called the **base section** or **boom butt.** The smallest section, at the top of the boom, is called the tip section or boom tip. In between there can be one or more sections called the **first, second, and so forth, sections.** With the boom fully retracted, the telescopic boom crane is highly maneuverable and easy to transport to jobsites. Telescopic boom crane nomenclature is shown in figure 12-27.

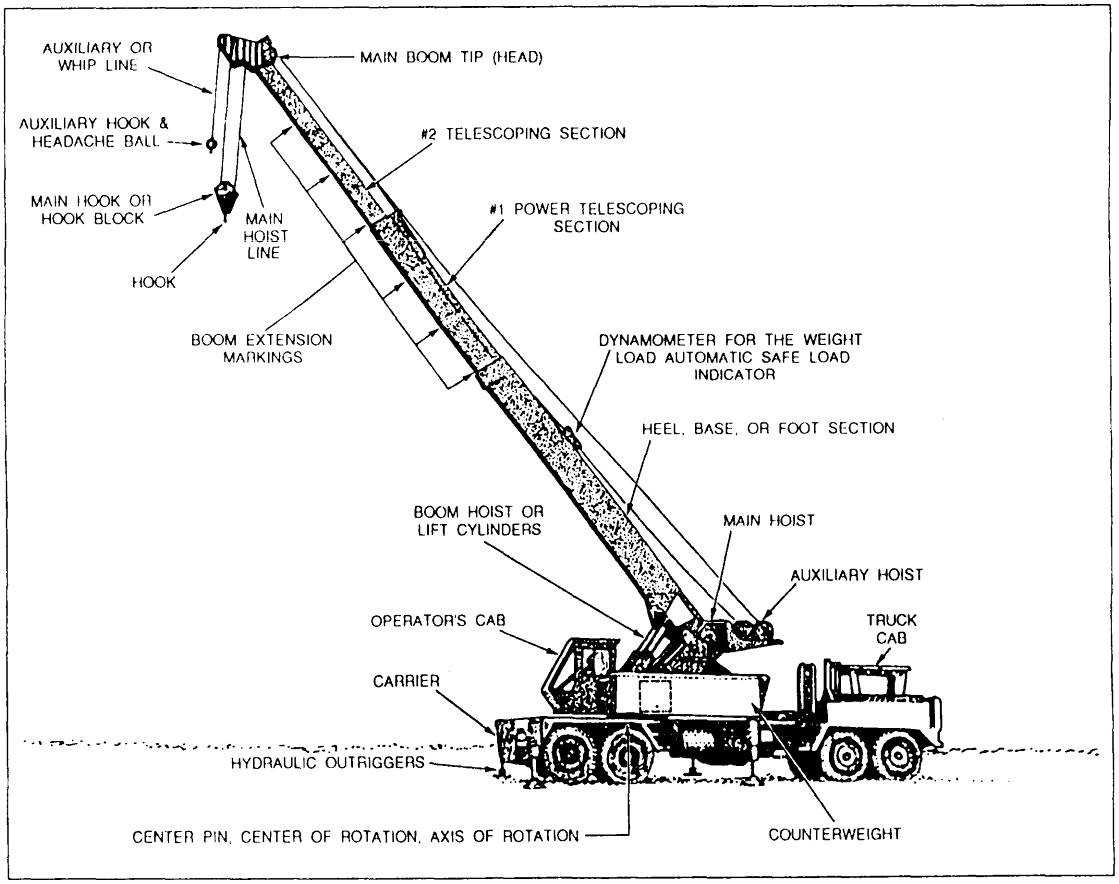

AUXILIARY OR WHIP LINE
MAIN BOOM TIP (HEAD)
AUXILIARY HOOK & HEADACHE BALL
#2 TELESCOPING SECTION
MAIN HOOK OR HOOK BLOCK
#1 POWER TELESCOPING SECTION
MAIN HOIST LINE
HOOK
BOOM EXTENSION MARKINGS
DYNAMOMETER FOR THE WEIGHT LOAD AUTOMATIC SAFE LOAD INDICATOR
HEEL, BASE, OR FOOT SECTION
BOOM HOIST OR LIFT CYLINDERS
MAIN HOIST
AUXILIARY HOIST
OPERATOR'S CAB
TRUCK CAB
CARRIER
HYDRAULIC OUTRIGGERS
CENTER PIN, CENTER OF ROTATION, AXIS OF ROTATION
COUNTERWEIGHT

Figure 12-27.—Telescopic boom crane nomenclature.

Sections

Telescopic booms may be **a pinned boom, full-powered boom,** or a combination of both. A "pinned boom" means sections are pinned in the extended or retracted position. A "full-powered boom" means sections extend or retract hydraulically. Some models have a full-powered main boom with a pinned boom tip section. Read the operator's manual for the proper operation of the type of boom that is equipped on the crane you are assigned to operate.

On a full-powered boom, the sections are extended and retracted (except for the base section) by hydraulic cylinders, called extension cylinders. The cylinders are mounted parallel to the boom center line within each section. The boom extension cylinders on most telescopic booms have sequencing valves that allow the sections to extend (telescope) by equal amounts. These cranes usually have a single telescope control lever in the cab. However, on cranes not equipped with sequencing valves, the operator will have to extend each section equally. (The crane will have two or three boom telescope control levers in the cab, each controlling only a single boom section.) If the boom sections are extended unequally, the most fully extended section of boom could bend to uneven stresses. Additionally, the load chart will be invalidated for determining rated capacity of the crane. Boom sections that are marked off in equal increments, as shown on the boom in figure 12-27, make it easier for the operator or signalman to make sure each section is extended equally.

When a load is placed on a telescopic boom, the load weight on the boom causes the hydraulic rams within the boom to stiffen up and slightly curve. As the load is removed from the boom, the rams return straight. Because of this, do not extend the boom while it is under load. Read the operator's manual for boom extension information.

Hoisting Mechanism

The hoisting mechanism for a telescopic crane is a hydraulically powered hoist drum. The hoist drum is mounted behind the boom on the crane house or revolving turntable. Some hydraulic cranes are equipped with two hoist drums: one for the main hoist and the second for the auxiliary or whip line.

House Assembly

The house assembly is a revolving unit that supports the boom. Some small hydraulic cranes have the operator's cab and counterweight attached to the revolving unit.

OPERATOR'S CAB.— The telescopic crane will have hoist, swing, and boom control levers similar to the cab of the lattice boom crane. Control lever(s) is/are also provided to extend and retract the boom. The hoist system does not require foot-controlled brakes. When the hoist control lever is returned to the neutral position, the hydraulic system holds the load in place.

POWER SOURCE.— The power for a telescopic crane comes from hydraulic fluid. In most cases, the main carrier engine drives the hydraulic pump that supplies the hydraulic fluid to hydraulically controlled components. Power is diverted to hydraulic motors or cylinders by the valve body at the operator's control station. The hydraulic power provides positive control of all crane functions.

COUNTERWEIGHT.— The counterweight on a telescopic crane provides greater stability when lifting loads. When you are performing near-capacity lifts at high boom angles using a telescopic crane, about 60 percent of load weight is placed on the outriggers away from the load. When you are performing the same lift with a lattice boom crane, about 60 percent of the load is placed on outriggers close to the load.

CRANE ATTACHMENTS

The crane is a versatile piece of equipment that can be equipped with various attachments to perform a number of different operations. These attachments include a hook block, a clamshell, and a dragline.

HOOK BLOCK

A crane that is rigged with a hook block is the primary unit for lifting an objector load, transferring it to a new place by swinging or traveling and then placing the load. Figure 12-28 shows an eight-part line rigged hook block.

The number of parts of a line rigged on the hook block is important for figuring the capacity of the crane. Most crane load charts show the rated capacity of the crane for different parts of the line; for example, a crane that is capable of being rigged with a eight-part line is rigged with a six-part line. The eight-part line gives the crane a greater lifting capacity; therefore, you must check the load chart for the six-part line capacity to avoid overloading the crane.

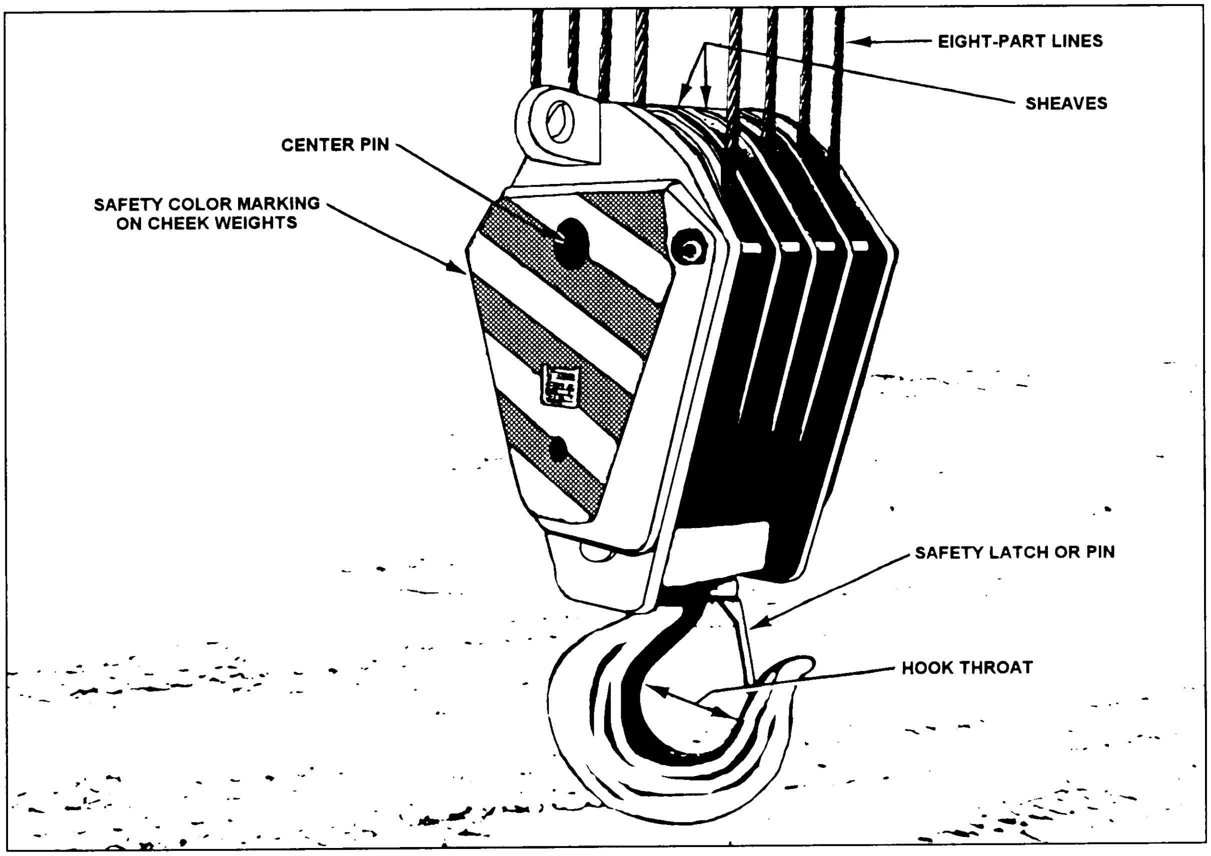

EIGHT-PART LINES
SHEAVES
CENTER PIN
SAFETY COLOR MARKING ON CHEEK WEIGHTS
SAFETY LATCH OR PIN
HOOK THROAT

Figure 12-28.-Hook block.

CLAMSHELL

A clamshell consists of hoist drum lagging, clamshell bucket, tag line, and wire ropes to operate holding and closing lines. On some crane models, the hoist drum lagging (hoist drum diameter) can be changed to meet the speed or pull requirements for clamshell operations. Once a crane is rigged with a clamshell, the crane is referred to by the name of the attachment.

When changing attachments from a hook block to a clamshell, check the operator's manual for the correct length of wire rope reeving; for example, some crane models require 300 to 400 feet of wire rope for hook block operations and only 100 to 200 feet of wire rope for clamshell operations. Too much wire rope on the hoist drum during clamshell operations will cause the wraps of wire rope to loosen on the hoist drum and cross wind, resulting in crushed wires and kink spots in the wire rope. This is very expensive, because the wire rope is usually no longer useful for hook block operations.

Changing the length of rope requires unreeving the hook block wire rope and reeving the correct length of wire rope for the clamshell. This may be a time-consuming effort, but saves you from having to replace 300 to 400 feet of wire rope when the crane is rigged for hook block operations.

The clamshell bucket (fig. 12-29) is two scoops hinged together in the center with counterweights

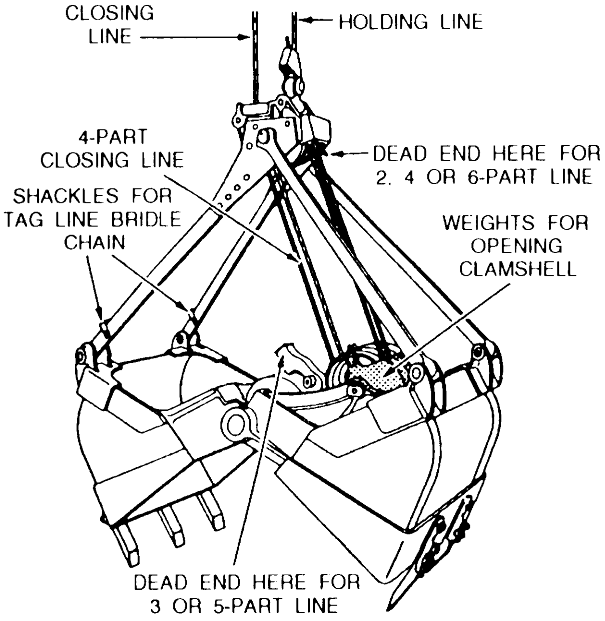

CLOSING LINE
HOLDING LINE
4-PART CLOSING LINE
DEAD END HERE FOR 2, 4 OR 6-PART LINE
SHACKLES FOR TAG LINE BRIDLE CHAIN
WEIGHTS FOR OPENING CLAMSHELL
DEAD END HERE FOR 3 OR 5-PART LINE

Figure 12-29.-Clamshell bucket.

bolted around the hinge. The two hoist drum wire ropes on the crane are rigged as the holding and closing lines for controlling of the bucket. An example of a clamshell rigging configuration is shown in figure 12-30.

The tag line winder (fig. 12-31) controls the tension on the tag line that helps prevent the clamshell from twisting during operations. Like the clamshell bucket, the tag line winder will exchange with most makes or models of cranes in the same-size range.

DRAGLINE

The dragline component (fig. 12-32) consists of a dragline bucket and fairlead assembly. The wire rope components of the dragline are the drag cable, the bucket hoist, and the dump. Once a crane is rigged with a dragline, the crane is referred to by the name of the attachment,

When you are loading the bucket, the fairlead (fig. 12-33) guides the drag cable onto the hoist drum. The hoist wire rope, which is reeved through the boom point sheaves, raises and lowers the bucket.

WARNING

> On some model of cranes, you must make sure the fairlead is in a vertical position when lowering the boom to avoid bending the cords of the boom base.

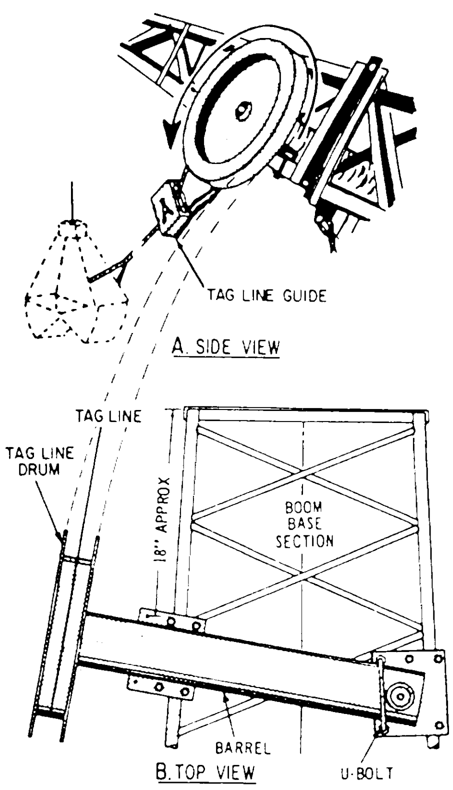

TAG LINE GUIDE
A. SIDE VIEW
TAG LINE
TAG LINE DRUM
18" APPROX
BOOM BASE SECTION
BARREL
B. TOP VIEW
U-BOLT

Figure 12-31.—Tag line winder.

When changing attachments from hook block or clamshell to dragline, check the operator's manual for the lengths and diameter size of wire rope required for dragline operations. The pulling force of the dragline

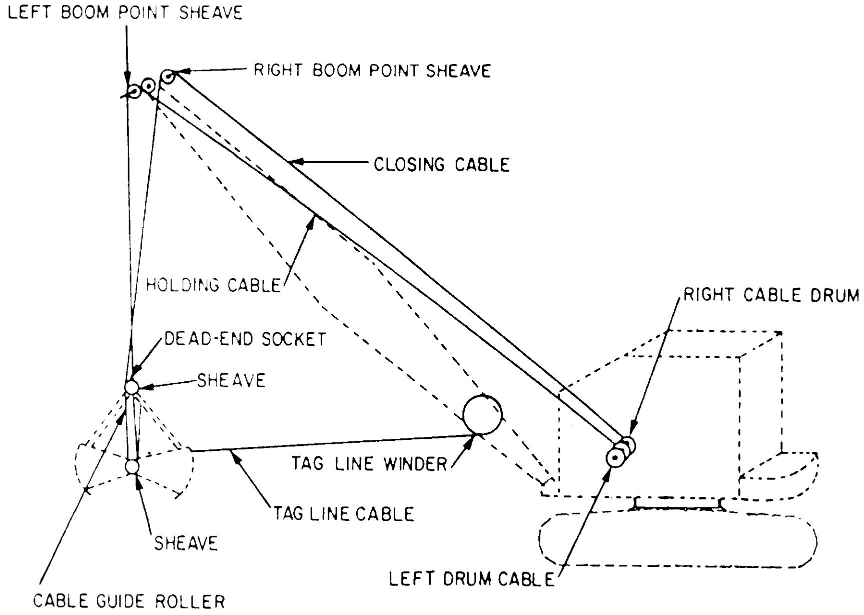

LEFT BOOM POINT SHEAVE
RIGHT BOOM POINT SHEAVE
CLOSING CABLE
HOLDING CABLE
RIGHT CABLE DRUM
DEAD-END SOCKET
SHEAVE
TAG LINE WINDER
TAG LINE CABLE
SHEAVE
LEFT DRUM CABLE
CABLE GUIDE ROLLER

Figure 12-30.-Clamshell rigging configuration.

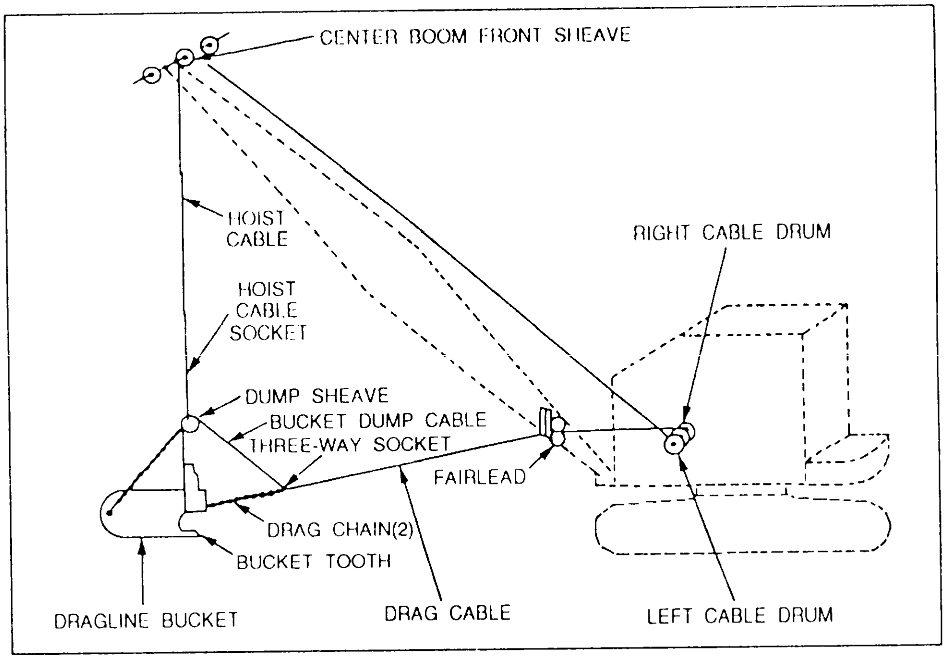

CENTER BOOM FRONT SHEAVE
HOIST CABLE
RIGHT CABLE DRUM
HOIST CABLE SOCKET
DUMP SHEAVE
BUCKET DUMP CABLE
THREE-WAY SOCKET
FAIRLEAD
DRAG CHAIN(2)
BUCKET TOOTH
DRAGLINE BUCKET
DRAG CABLE
LEFT CABLE DRUM

Figure 12-32.-Dragline.

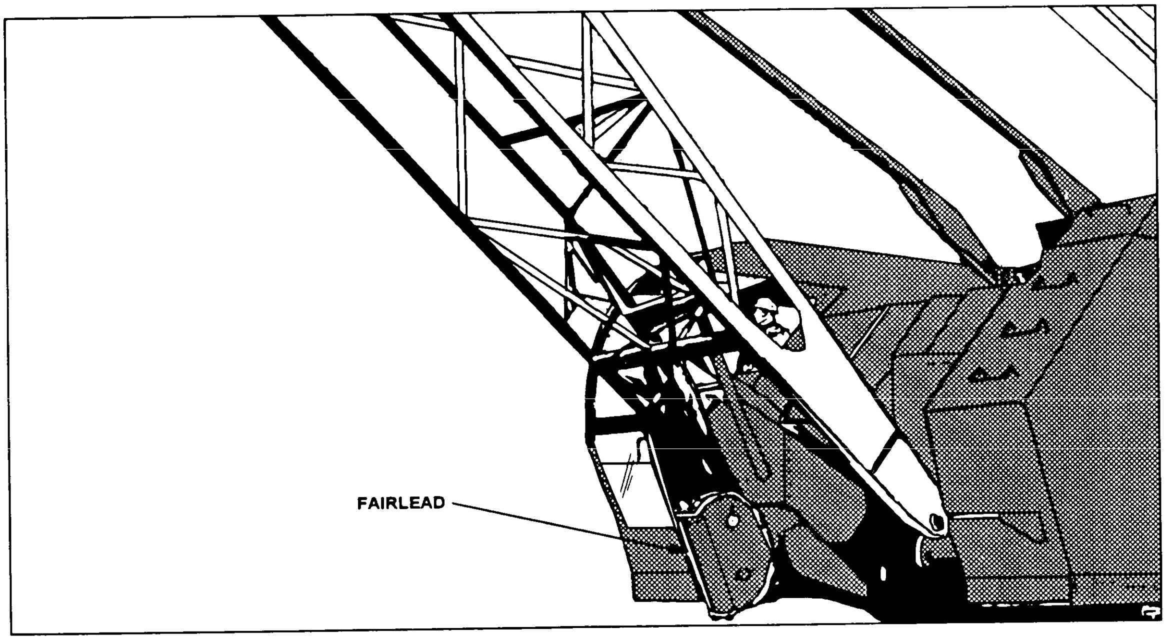


Figure 12-33.—Dragline fairlead.

normally requires a larger diameter drag cable. The length of the hoist wire rope is also shorter than normal to avoid cross winding on the hoist drum. The drag cable pulls the bucket through the material when digging. When the bucket is raised by the hoist wire rope and moved to the dump point, dump the bucket by releasing the tension on the drag cable.

NOTE: Do not lubricate the drag cable. If the drag cable is lubricated and pulled through the dirt, it retains the dirt, which causes damage to the wire rope.

The construction industry rates dragline buckets in different types and classes. The types and classes are as follows:

- Type I (light duty)
- Type II (medium duty)
- Type III (heavy duty)
- Class P (perforated plate)
- Class S (solid plate)

The most common buckets used by the Navy are the type II, class S buckets. Class P buckets are available for dredging operations. Figure 12-34 shows the makeup of a drag bucket.

CRANE OPERATIONS

People are crippled or killed and enormous property damage is incurred as a direct result of crane mishaps. Most of these crane mishaps result from **OPERATOR ERROR.** The Naval Construction Force (NCF) has an extensive crane safety program that applies to crane operators and the safe operation of weight-handling equipment.

Standards for weight-handling equipment operations are outlined in the *Management of Weight-Handling Equipment,* NAVFAC P-307; *NCF Equipment Management Manual,* NAVFAC P-404; *NMCB Equipment Management,* COMSECOND/ COMTHIRDNCBINST 11200.1; *Use of Wire Rope Slings and Rigging Hardware in the NCF,* COMSECOND/COMTHIRDNCBINST 11200.11; and *Testing and Licensing of Construction Equipment Operators,* NAVFAC P-306.

CRANE CREW

The skills and safety standards demanded for efficient crane operations require only mature professionals be assigned as crane operators and riggers. The supervisor of the crane crew is normally the best crane operator available within the battalion-wide assets and is assigned and designated in writing by the commanding officer. The equipment officer, the crane test director, and the crane crew supervisor share the responsibility of ensuring that any personnel that prepares, assembles, operates, or works with or around cranes are well trained in both safety and operating procedures.

Before you receive a license to operate a crane, crane operators are required to attend 40 hours of formal classroom instruction on crane operating safety, as outlined in NAVFAC P-306. Additionally, operators who need to renew their license must attend a minimum

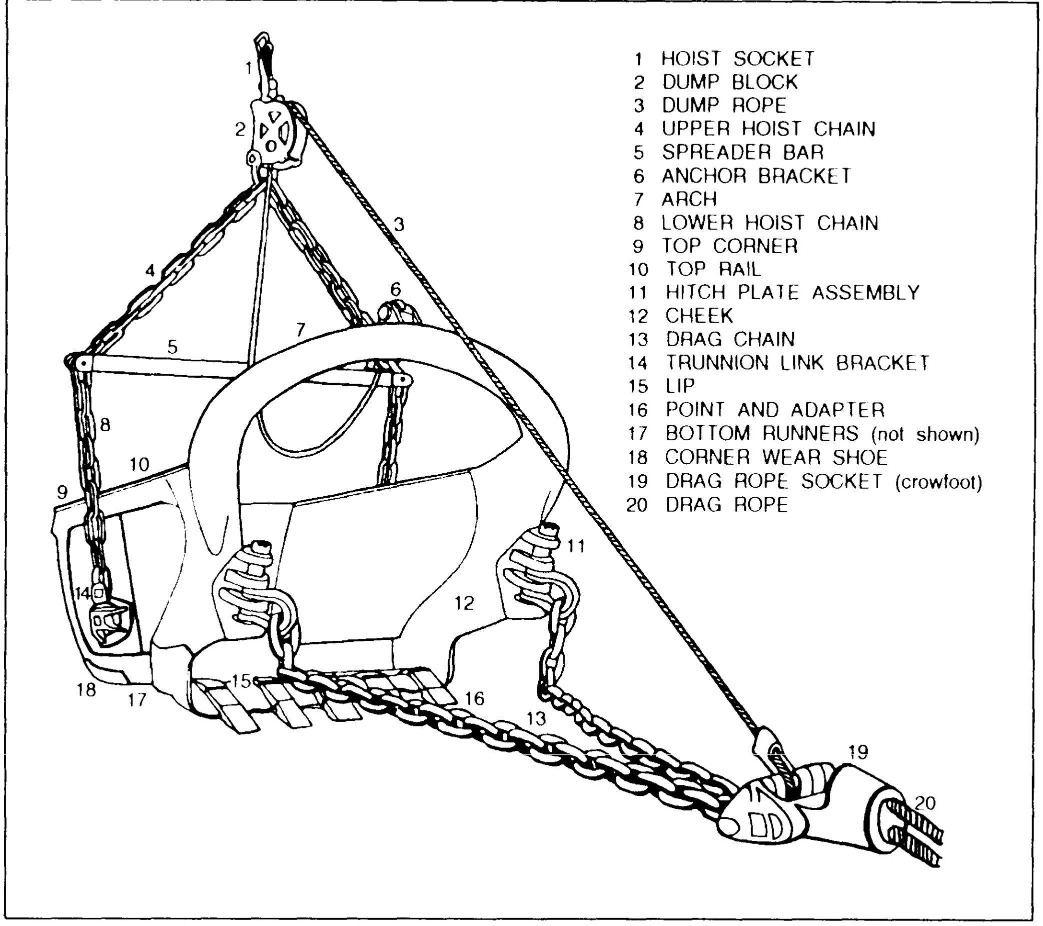

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1 HOIST SOCKET
2 DUMP BLOCK
3 DUMP ROPE
4 UPPER HOIST CHAIN
5 SPREADER BAR
6 ANCHOR BRACKET
7 ARCH
8 LOWER HOIST CHAIN
9 TOP CORNER
10 TOP RAIL
11 HITCH PLATE ASSEMBLY
12 CHEEK
13 DRAG CHAIN
14 TRUNNION LINK BRACKET
15 LIP
16 POINT AND ADAPTER
17 BOTTOM RUNNERS (not shown)
18 CORNER WEAR SHOE
19 DRAG ROPE SOCKET (crowfoot)
20 DRAG ROPE

Figure 12-34.-Dragline bucket.

8-hour refresher training course on crane operator safety.

The testing of crane operators is the direct responsibility of the crane certifying officer. The crane certifying officer may be assisted in administering a performance test by the crane test director. The equipment officer is normally responsible for the duties of the crane certifying officer and is designated in writing by the commanding officer. The crane certifying officer designates in writing the crane test director and all crane test personnel. Crane license is issued on the Construction Equipment Operator License, NAVFAC 11260/2, and will indicate the make, model, capacity, and the attachments the operator is qualified to operate.

Signalman

The signalman is part of the crane crew and is responsible to the operator to give signals for lifting, swinging, and lowering loads. A signalman should be a qualified seasoned crane operator. Not only does the signalman give signals for handling loads but the signalman can visually observe what the operator cannot see from the operator's cab. For example, during a lift the signalman should make a visual check of the following:

1. The load hook is centered over the center of balance of the load, as the weight is being lifted by the crane.

2. The boom deflection does not exceed the safe load radius.

3. All the rigging gear is straight and not causing damage to itself or the load.

4. During a lift with a lattice boom crane, check the boom suspension system and boom hoist reeving to ensure proper operation.

5. Check the hook block and boom tip sheaves reeving to ensure proper operation.

6. Check the stability of the outriggers especially when swinging from one quadrant of operation to another.

NOTE: On some cranes, the capacity of the crane changes when swinging from the rear quadrant to over-the-side quadrant.

7. Use tag lines and tag line handlers to prevent the load from swinging or twisting.

WARNING

Allowing personnel to control a load by the use of hands puts them in great danger should the load fall or some unexpted mishap occurs.

8. Signal only to lift the load high enough to clear any obstacles.

9. ALWAYS have eye-to-eye contact with the crane operator. The crane operator depends on the signalman to lift, swing, and lower a load safely.

The signalman must also know the load weight being lifted and the radius and capacity of the crane. The basic hand signals used throughout the NCF are in appendix IV of this TRAMAN. Only one person gives signals to the operator. The only time anyone else should give a signal is for an **EMERGENCY STOP.**

Rigger

The rigger or riggers are responsible to the operator for properly attaching the rigging gear to the load. Rigging can be an extremely dangerous job if not properly performed. Safety gear, such as hard hats, steel-toed shoes, gloves, and any other personal safety clothing needed, must be worn.

Riggers and signalman must work closely together after the load is rigged. The signalman visually checks for proper rigging that the operator cannot visually see from the operator's cab. Once the rigging is approved, then the load can be signaled to be lifted.

NOTE: The operator has the final approval on any lift and has the ultimate responsibility for the crane lift and safety.

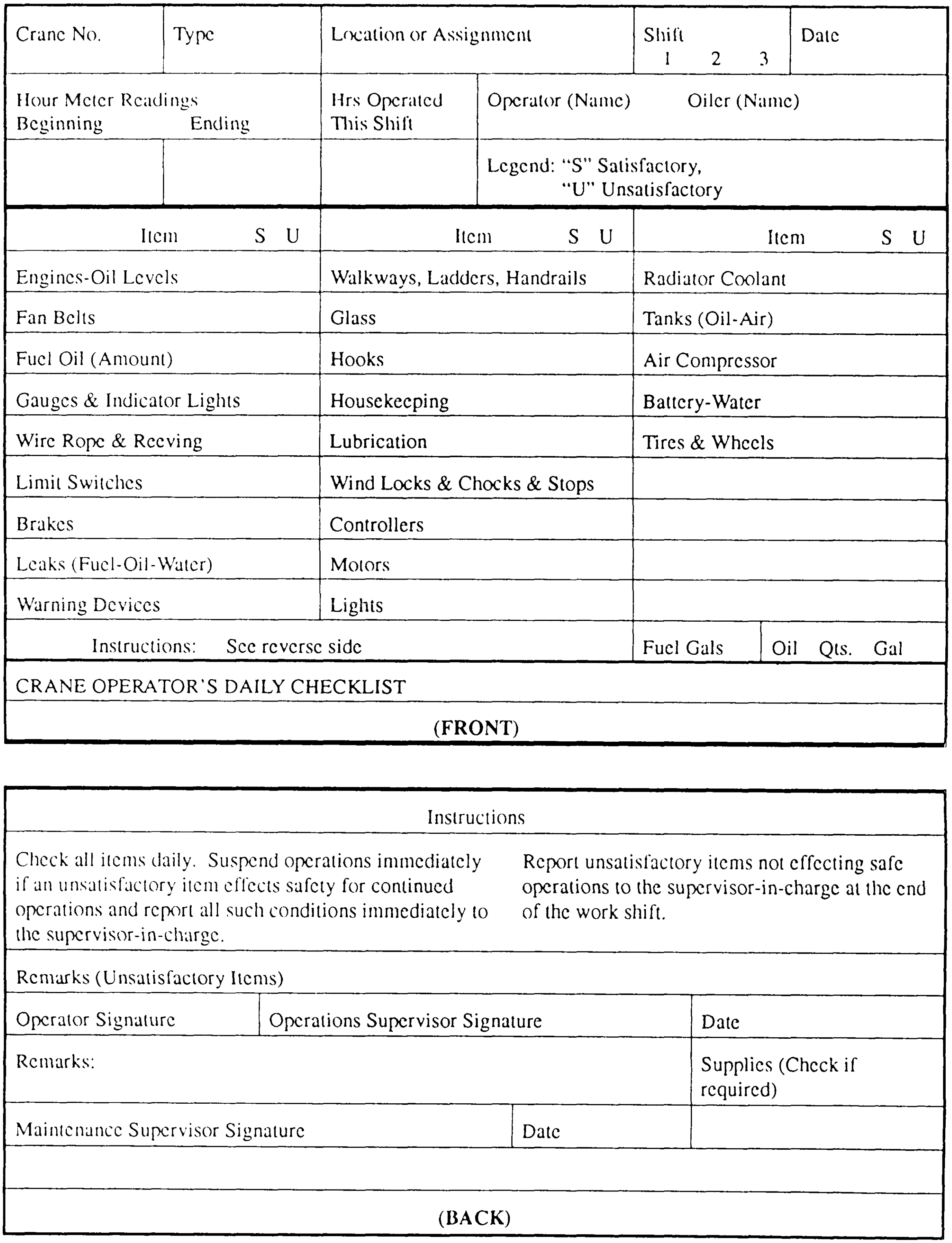
Operator

The operator pulls the levers on the crane and is directly responsible for the crane, the load rigging, and the lifts performed. You must know the crane, how to operate it, how it responds under loaded and unloaded conditions, proper rigging procedures, and signaling. You must be able to set the crane up properly for lifts, always keeping in mind that safety comes first and production second.

CRANE OPERATOR'S DAILY INSPECTION

Before a crane is operated or transported, it must be thoroughly inspected by the operator. The operator uses the Crane Operator's Daily Checklist (ODCL) (fig. 12-35). The operator visually inspects and checks each item prescribed on the checklist.

When the operator observes a deficiency of a **load-bearing** or **load-controlling** part or safety device (major deficiency) or an operating condition that would cause the slightest loss of control or otherwise render



Crane No.	Type	Location or Assignment	Shift 1 2 3	Date
Hour Meter Readings Beginning Ending		Hrs Operated This Shift	Operator (Name) Oiler (Name)	
			Legend: "S" Satisfactory, "U" Unsatisfactory	

Item S U	Item S U	Item S U	
Engines-Oil Levels	Walkways, Ladders, Handrails	Radiator Coolant	
Fan Belts	Glass	Tanks (Oil-Air)	
Fuel Oil (Amount)	Hooks	Air Compressor	
Gauges & Indicator Lights	Housekeeping	Battery-Water	
Wire Rope & Reeving	Lubrication	Tires & Wheels	
Limit Switches	Wind Locks & Chocks & Stops		
Brakes	Controllers		
Leaks (Fuel-Oil-Water)	Motors		
Warning Devices	Lights		
Instructions: See reverse side		Fuel Gals	Oil Qts. Gal

CRANE OPERATOR'S DAILY CHECKLIST

(FRONT)

Instructions

Check all items daily. Suspend operations immediately if an unsatisfactory item effects safety for continued operations and report all such conditions immediately to the supervisor-in-charge.	Report unsatisfactory items not effecting safe operations to the supervisor-in-charge at the end of the work shift.

Remarks (Unsatisfactory Items)			
Operator Signature	Operations Supervisor Signature		Date
Remarks:			Supplies (Check if required)
Maintenance Supervisor Signature		Date	

(BACK)

Figure 12-35.—Crane Operator's Daily Checklist.

the crane unsafe, the operator must secure the crane and notify the crane crew supervisor.

The Operator's Daily PM Report, NAVFAC Form 11260/4, is also used with the ODCL when performing the crane prestart inspection. The ODCL is turned in to the crane crew supervisor at the end of each day or shift for reviewing and signing. The NAVFAC Form 11260/4 is turned in to dispatch. As outlined in the NAVFAC P-307, the minimum requirement for retaining ODCLs is those completed during the current month and during the previous month of operation.

Wire Rope Inspection

Part of the ODCL inspection is the thorough inspection of all wire rope before using a crane. All running rope in continuous service must be visually inspected for crushing, kinking, corrosion or other damage, broken wires, and proper lubrication (fig. 12-36).

Other areas to inspect are wire rope sockets, swage fittings, swivels, pendants, and securing hardware for wear. Hoist drum end fittings need only be disconnected or disassembled when experience or visible indications deem it necessary.

The exact time for replacement of wire rope cannot be given because many variables are involved; however, safety depends upon the use of good judgment in evaluating wire rope.

The following conditions are reasons for wire rope replacement:

1. Running ropes. six or more broken wires randomly distributed, broken or torn wires in one lay, or three broken wires in one strand in one lay. Replace end

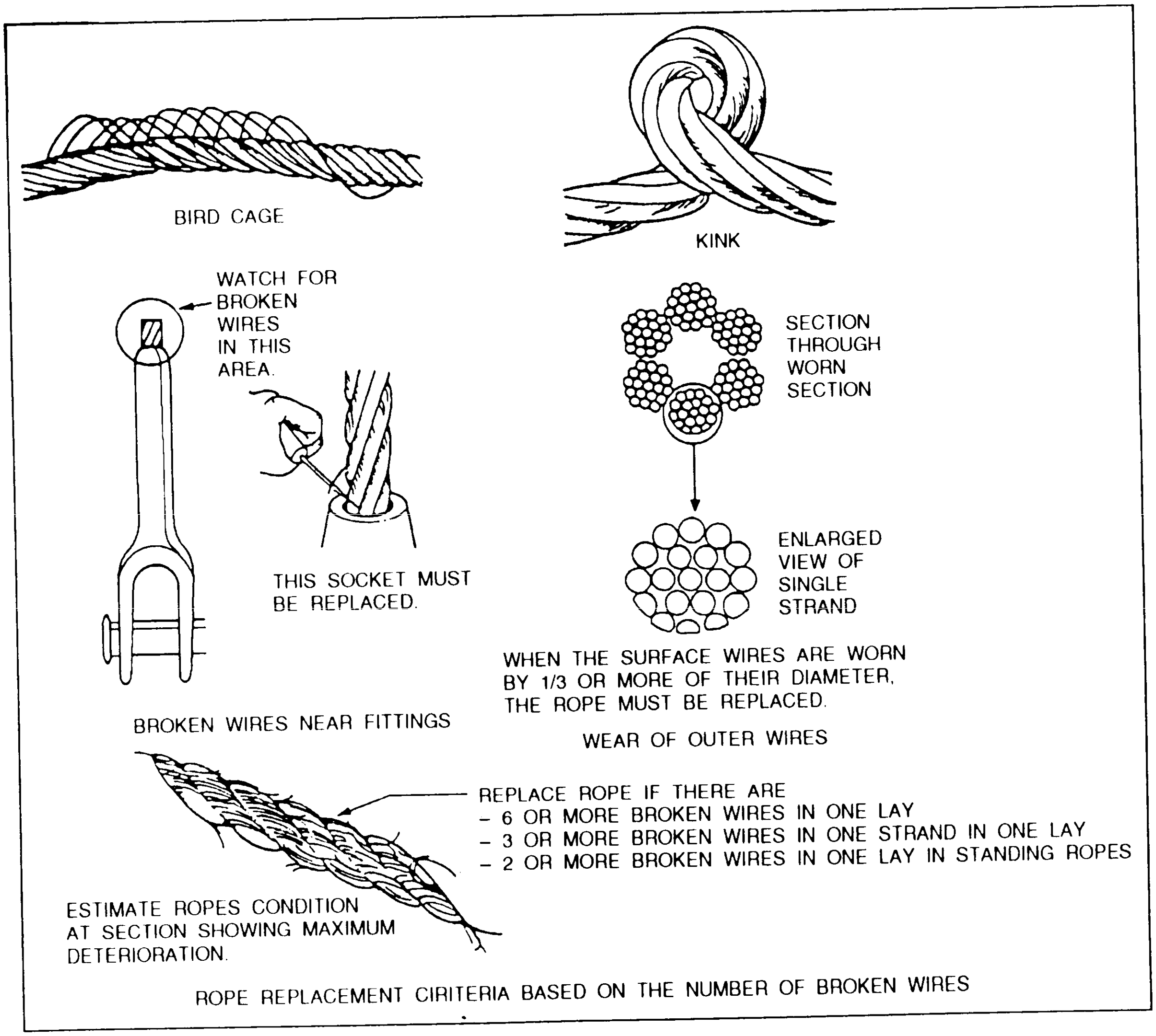

BIRD CAGE
KINK
WATCH FOR BROKEN WIRES IN THIS AREA.
THIS SOCKET MUST BE REPLACED.
BROKEN WIRES NEAR FITTINGS
SECTION THROUGH WORN SECTION
ENLARGED VIEW OF SINGLE STRAND
WHEN THE SURFACE WIRES ARE WORN BY 1/3 OR MORE OF THEIR DIAMETER, THE ROPE MUST BE REPLACED.
WEAR OF OUTER WIRES
REPLACE ROPE IF THERE ARE
- 6 OR MORE BROKEN WIRES IN ONE LAY
- 3 OR MORE BROKEN WIRES IN ONE STRAND IN ONE LAY
- 2 OR MORE BROKEN WIRES IN ONE LAY IN STANDING ROPES
ESTIMATE ROPES CONDITION AT SECTION SHOWING MAXIMUM DETERIORATION.
ROPE REPLACEMENT CIRITERIA BASED ON THE NUMBER OF BROKEN WIRES

Figure 12-36.—Common wire rope defects.

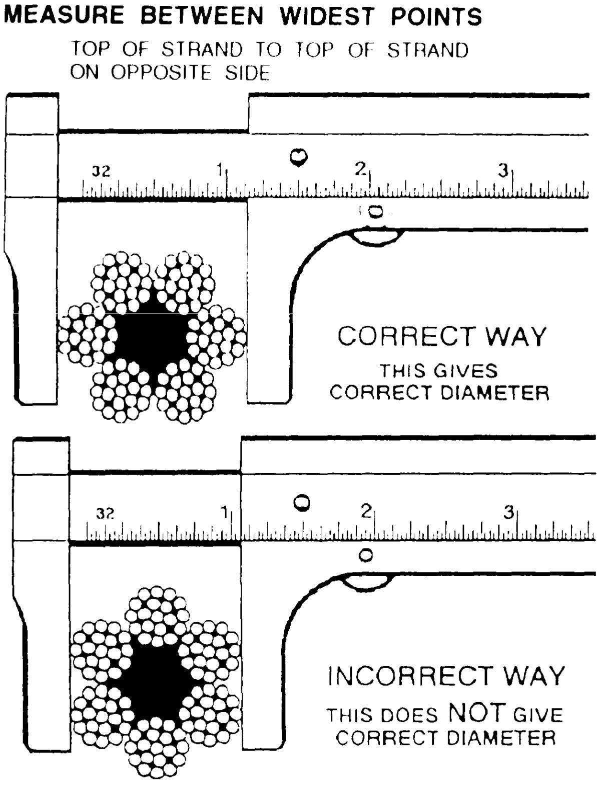

MEASURE BETWEEN WIDEST POINTS
TOP OF STRAND TO TOP OF STRAND ON OPPOSITE SIDE
32
1
2
3
CORRECT WAY
THIS GIVES CORRECT DIAMETER
32
1
2
3
INCORRECT WAY
THIS DOES NOT GIVE CORRECT DIAMETER

Figure 12-37.—Measuring wire rope.

connections when there are any broken wires adjacent to the end connection.

2. Boom pendant wire ropes. More than two broken wires in one lay in sections beyond the end connection or one or more broken wires at an end connection.

3. Kinks or crushed sections. Severe kinks or crushed rope in straight runs where the wire rope core is forced through the outer strands.

4. Flattened section. Flat sections where the diameter across the flat section is less than five sixths of the original diameter.

5. Wire rope wear. Measure wire rope with wire rope calipers (fig. 12-37) to check for wear accurately. Replace why rope that has wear of one third of the original diameter of outside individual wires. A crescent wrench can be used as an expedient means to measure wire rope.

Hook Block Inspection

The hook block and the hook are part of the ODCL inspection. The operator must inspect the hook block for cleanliness, binding sheaves, damaged or worn sheaves, worn or distorted sheave pins, broken bolts, and worn cheek weights (fig. 12-38).

The hook is inspected for damage, excessive wear to the hook safety latch, hook swivel trunnions, thrust collar, and securing nut. Also, the hook is inspected for damage or missing lubrication fittings, proper lubrication, cracks and gouges, and if visibly bent or twisted.

Sheave Inspection

The sheaves inspection (fig. 12-39) is the inspection for wear and damage, wear in the wire rope sheave groove, loose or damage sheave guards, and worn bearings and pins. Sheaves rotate on either bearings or bushings that are inspected for discoloration (due to

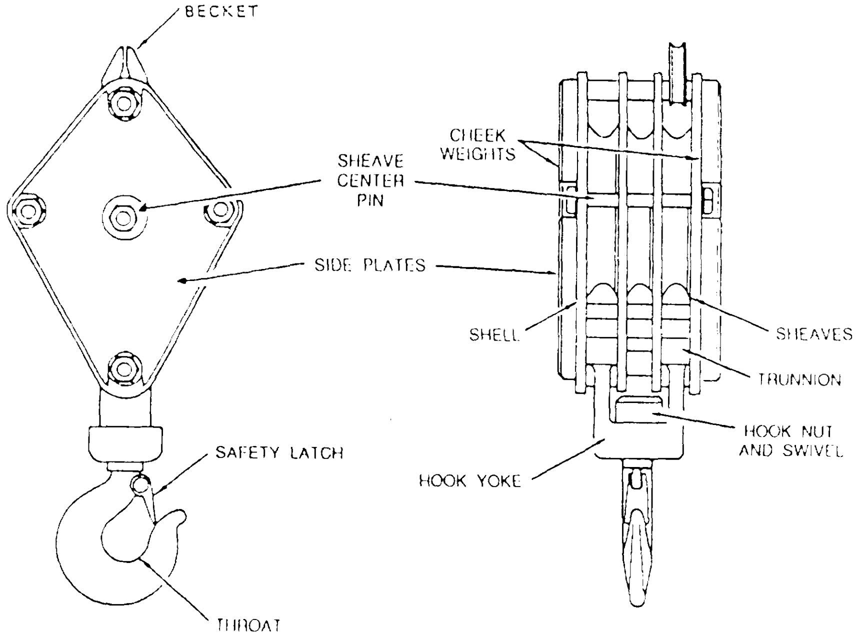

BECKET
CHEEK WEIGHTS
SHEAVE CENTER PIN
SIDE PLATES
SHELL
SHEAVES
TRUNNION
HOOK NUT AND SWIVEL
SAFETY LATCH
HOOK YOKE
THROAT

Figure 12-38.-Hook and block inspection points.

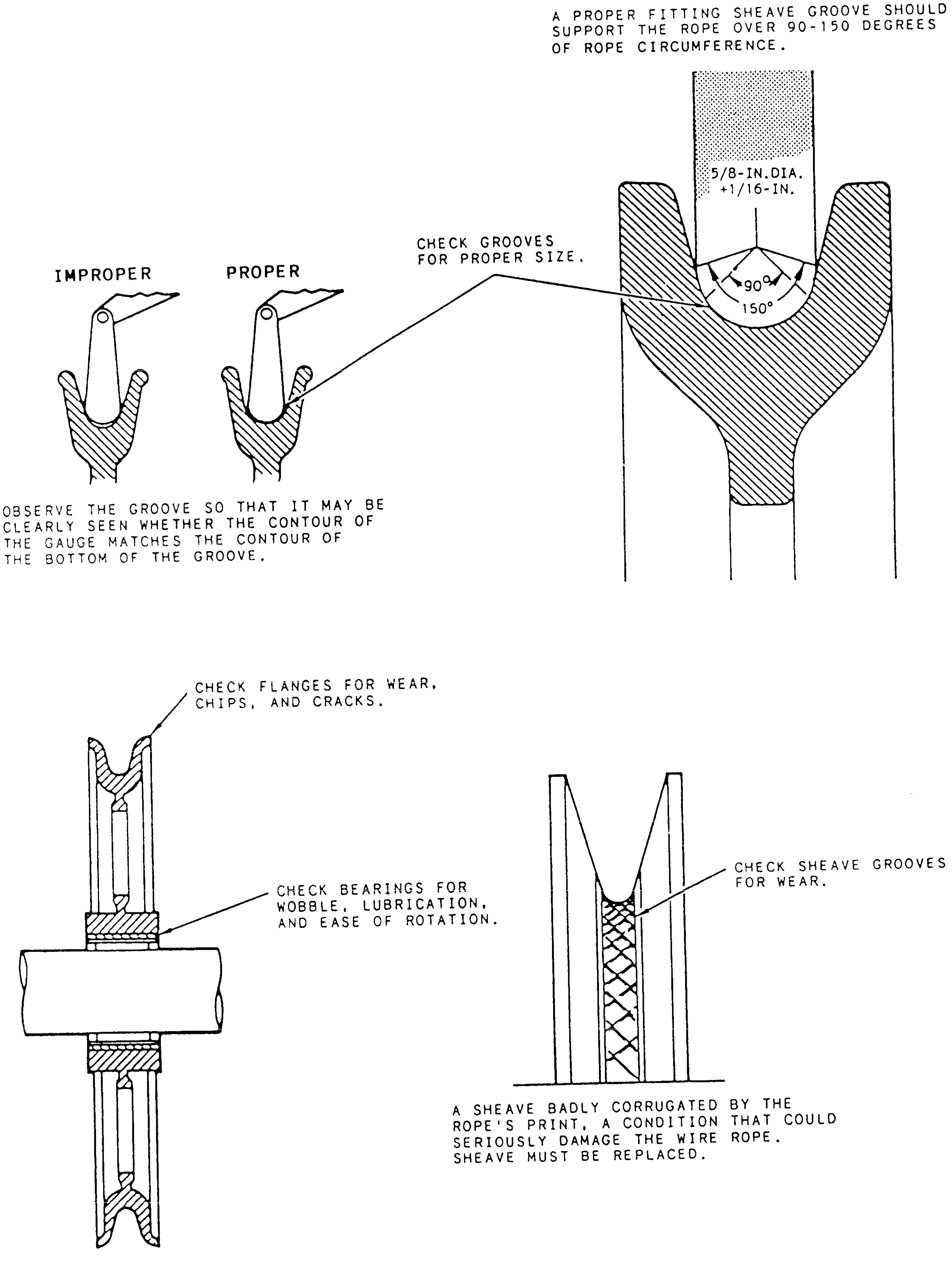

A PROPER FITTING SHEAVE GROOVE SHOULD SUPPORT THE ROPE OVER 90-150 DEGREES OF ROPE CIRCUMFERENCE.
5/8-IN.DIA. +1/16-IN.
90°
150°
CHECK GROOVES FOR PROPER SIZE.
IMPROPER
PROPER
OBSERVE THE GROOVE SO THAT IT MAY BE CLEARLY SEEN WHETHER THE CONTOUR OF THE GAUGE MATCHES THE CONTOUR OF THE BOTTOM OF THE GROOVE.
CHECK FLANGES FOR WEAR, CHIPS, AND CRACKS.
CHECK BEARINGS FOR WOBBLE, LUBRICATION, AND EASE OF ROTATION.
CHECK SHEAVE GROOVES FOR WEAR.
A SHEAVE BADLY CORRUGATED BY THE ROPE'S PRINT, A CONDITION THAT COULD SERIOUSLY DAMAGE THE WIRE ROPE. SHEAVE MUST BE REPLACED.

Figure 12-39.-Sheave (pulley) inspection.

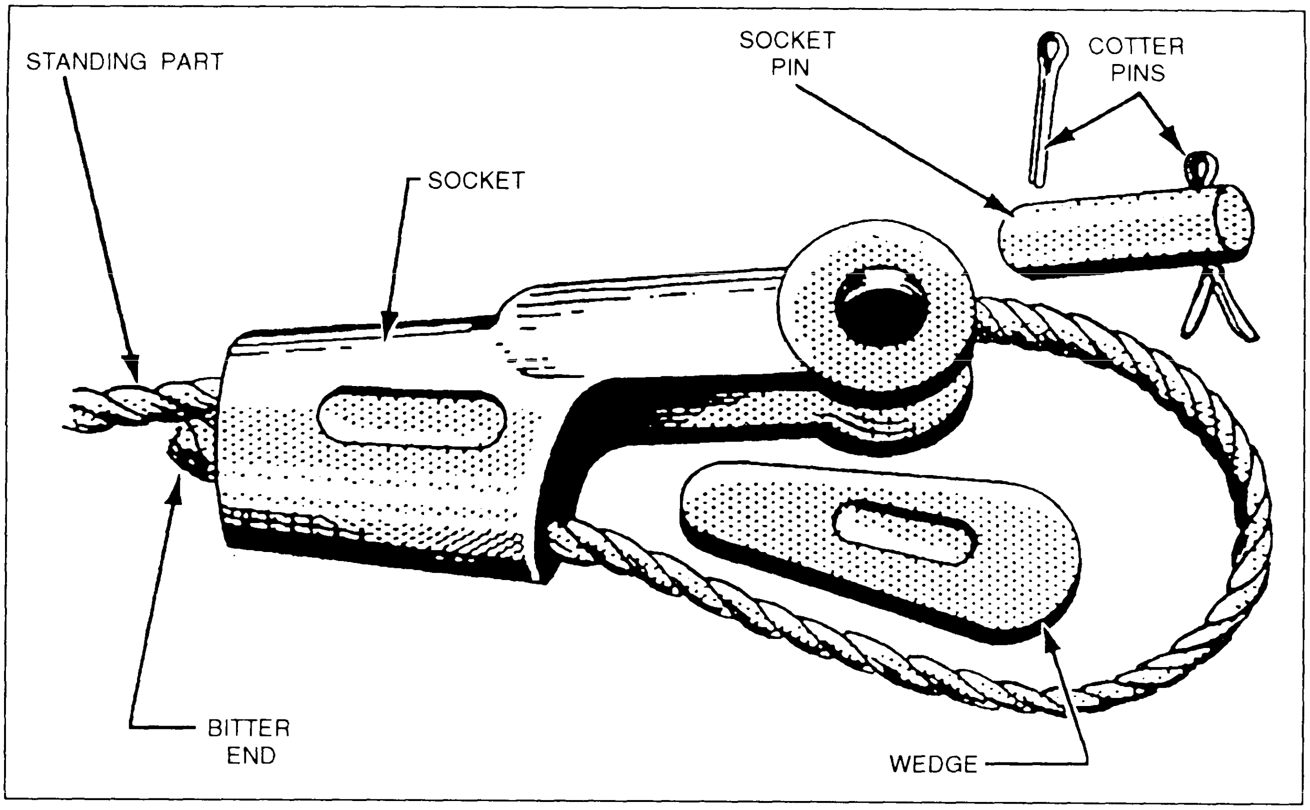


Figure 12-40.-Wedge socket.

excessive heat), metallic particles, chips or displaced metal, broken or distorted bearing retainer or seals, adequate lubrication, and tight bearing caps.

Wire Rope End Connections

Wire rope end connections must be as specified by the manufacture. The most common type of end connection used in the NCF is the wedge socket (fig. 12-40).

Wedge sockets develop only 70 percent of the breaking strength of the wire rope due to the crushing action of the wedge. Swage socket, cappel socket, and zinc (spelter) socket wire rope end connections all provide 100 percent of the breaking strength of the wire rope when properly made.

Exercise caution when wedge socket connections are used to make rated capacity lifts. Wedge sockets are particularly subject to wear, faulty component fit, and damage from frequent change outs, and are highly vulnerable to inadvertent wedge release and disassembly in a two-blocking situation.

NOTE: Two-blocking is hoisting the hook block sheaves against the boom tip sheaves.

Wedge sockets must be installed as specified in the following procedures:

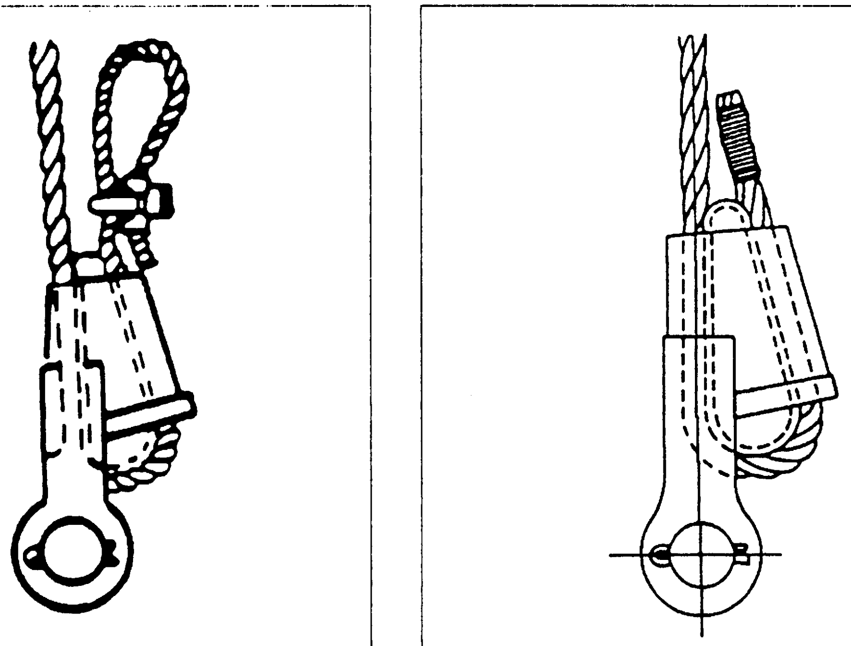
1. Cut and remove any section of wire rope used in a socket that was subject to sharp bending and crushing before resocketing.

2. Install the wedge socket carefully, so the wire rope carrying the load is in direct alignment with the eye of the socket clevis pin. This ensures the load pull is direct.

3. Place the socket upright and bring the rope around in a large, easy-to-handle loop. Extend the dead end of the wire rope from the socket for a distance of at least one rope lay length. Insert the wedge in the socket, permitting the rope to adjust around the wedge.

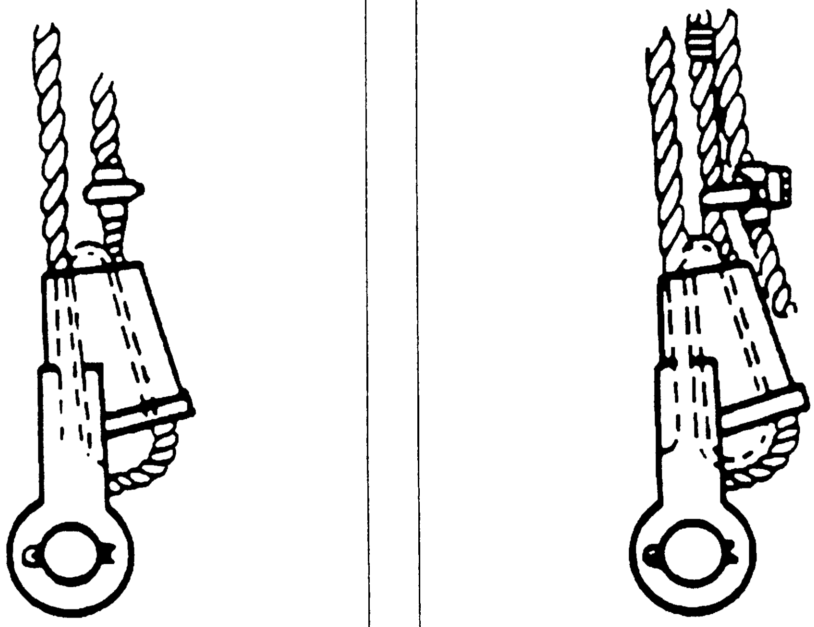
4. As a safety precaution, install a wire rope clip on the dead end of the wire rope that comes out of the wedge socket (fig. 12-41). Measure the distance from the base of the wedge socket to the clamp. This measurement is used as a guide to check if the wire rope is slipping in the wedge socket.

NOTE: Do not attach the wire rope clip to the dead end and live end of the wire rope that comes out of the



LOOP BACK METHOD

NO CLIP



SPECIAL-CLIP METHOD

EXTRA PIECE OF SAME-SIZE ROPE IS CLIPPED TO MAIN ROPE

Figure 12-41.—Wedge socket clip method.

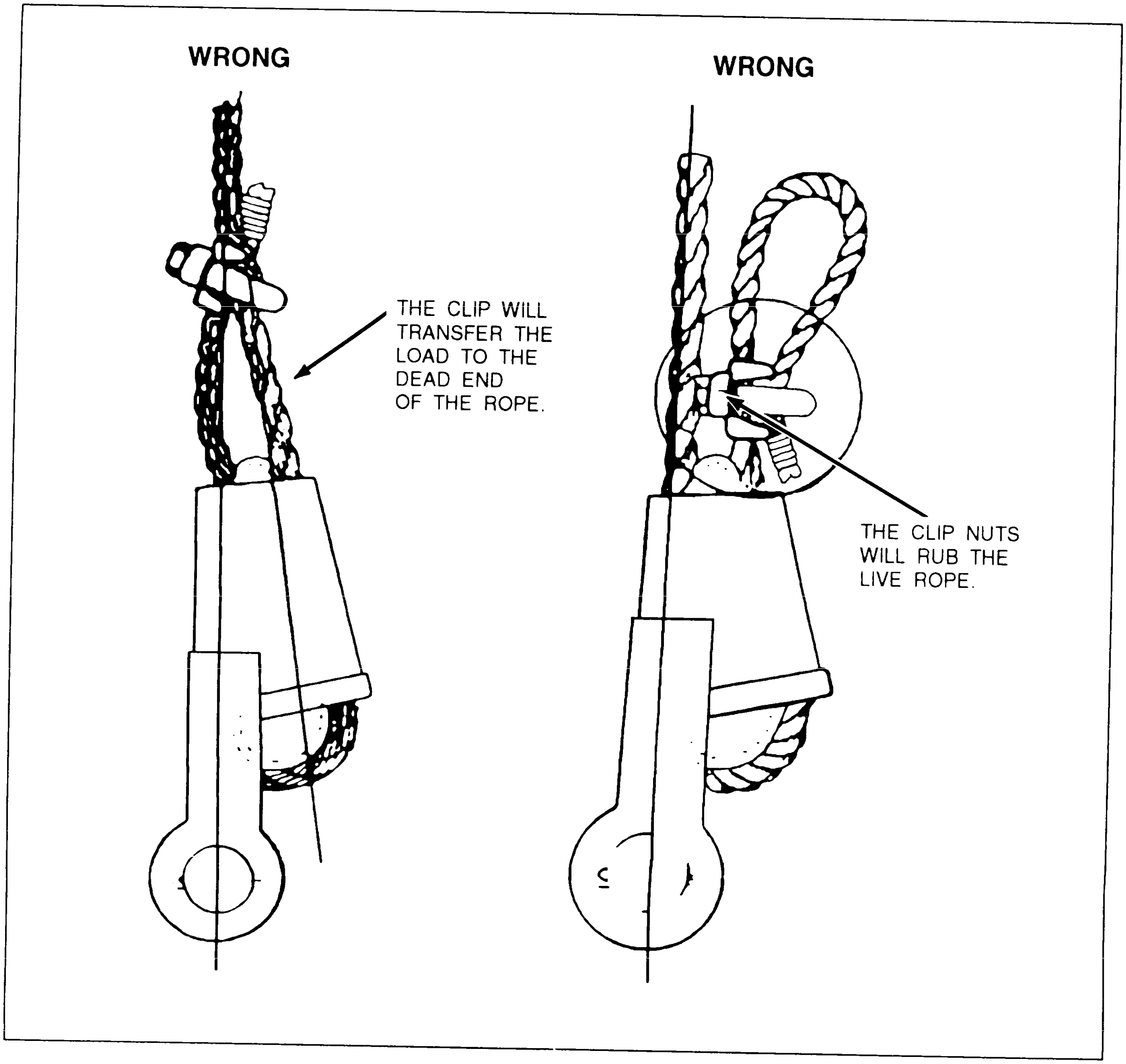

WRONG
WRONG
THE CLIP WILL TRANSFER THE LOAD TO THE DEAD END OF THE ROPE.
THE CLIP NUTS WILL RUB THE LIVE ROPE.

Figure 12-42.—Improper wire rope clip placement.

wedge socket. Improper wire rope clip placement is shown in figure 12-42.

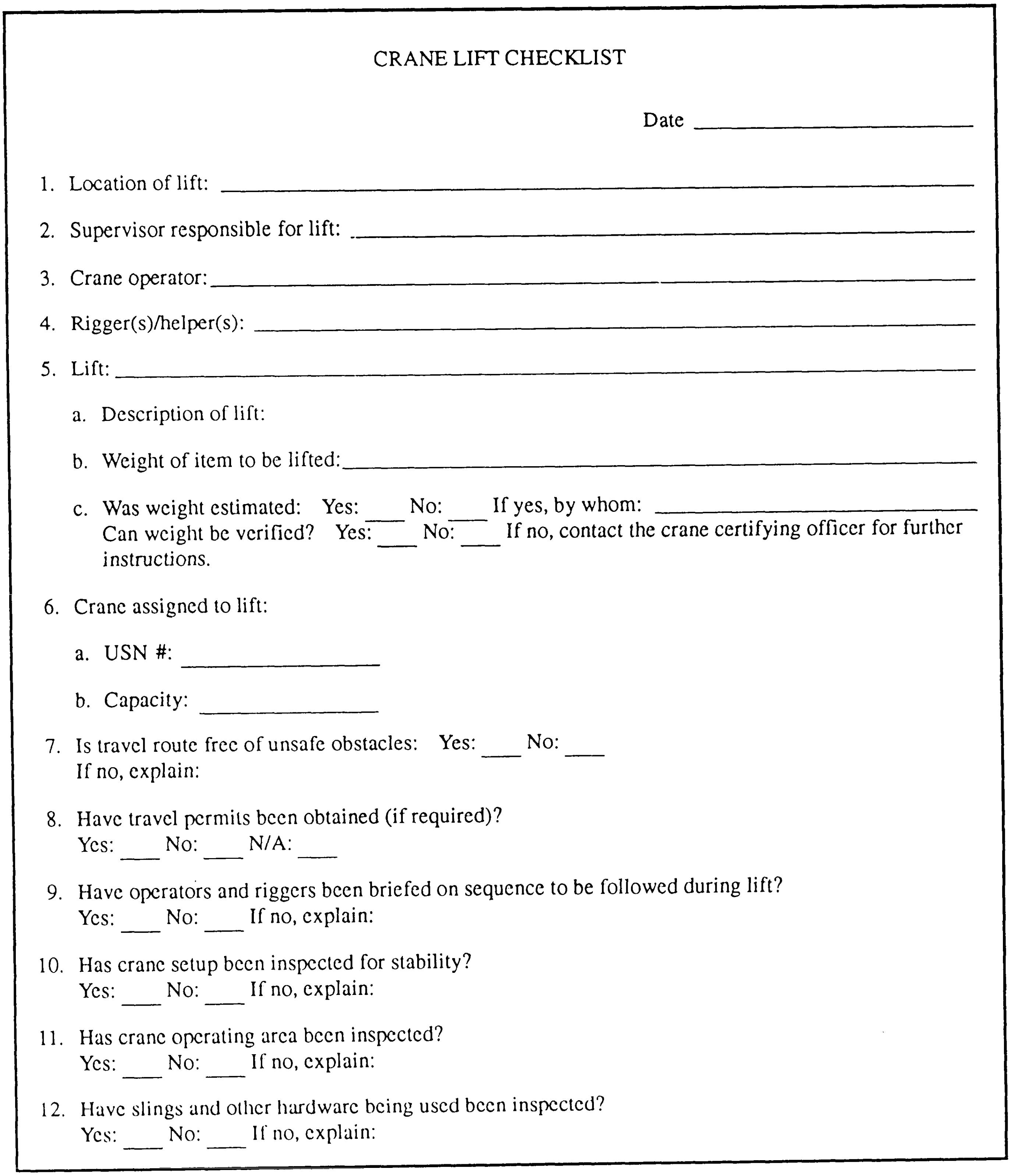
5. Secure the socket to a support and carefully take a strain on the live side of the rope to ensure the proper initial seating of the wedge. Increase the load gradually until the wedge is fully seated. Avoid sudden shock loads.

CRANE LIFT CHECKLIST

The Crane Lift Checklist (fig. 12-43), outlined in the COMSECOND/COMTHIRDNCBINST 11200.1, must be filled out by the crane crew supervisor or the crane test director before the crane can proceed to any project or make any crane lift. After the Crane Lift Checklist is complete, the crane crew supervisor briefs the operator and rigger on specifics of the lift and travel conditions.

Crane Stability

Setting up for a crane lift is the most critical portion of the crane operation. The most common causes of crane mishaps are as follows:



CRANE LIFT CHECKLIST

Date ____________________

1. Location of lift: ______________________________
2. Supervisor responsible for lift: ______________________________
3. Crane operator: ______________________________
4. Rigger(s)/helper(s): ______________________________
5. Lift: ______________________________
    a. Description of lift:
    b. Weight of item to be lifted: ______________________________
    c. Was weight estimated: Yes: ___ No: ___ If yes, by whom: ____________________
    Can weight be verified? Yes: ___ No: ___ If no, contact the crane certifying officer for further instructions.
6. Crane assigned to lift:
    a. USN #: ______________
    b. Capacity: ______________
7. Is travel route free of unsafe obstacles: Yes: ___ No: ___
    If no, explain:
8. Have travel permits been obtained (if required)?
    Yes: ___ No: ___ N/A: ___
9. Have operators and riggers been briefed on sequence to be followed during lift?
    Yes: ___ No: ___ If no, explain:
10. Has crane setup been inspected for stability?
    Yes: ___ No: ___ If no, explain:
11. Has crane operating area been inspected?
    Yes: ___ No: ___ If no, explain:
12. Have slings and other hardware being used been inspected?
    Yes: ___ No: ___ If no, explain:

Figure 12-43.-Crane Lift Checklist.

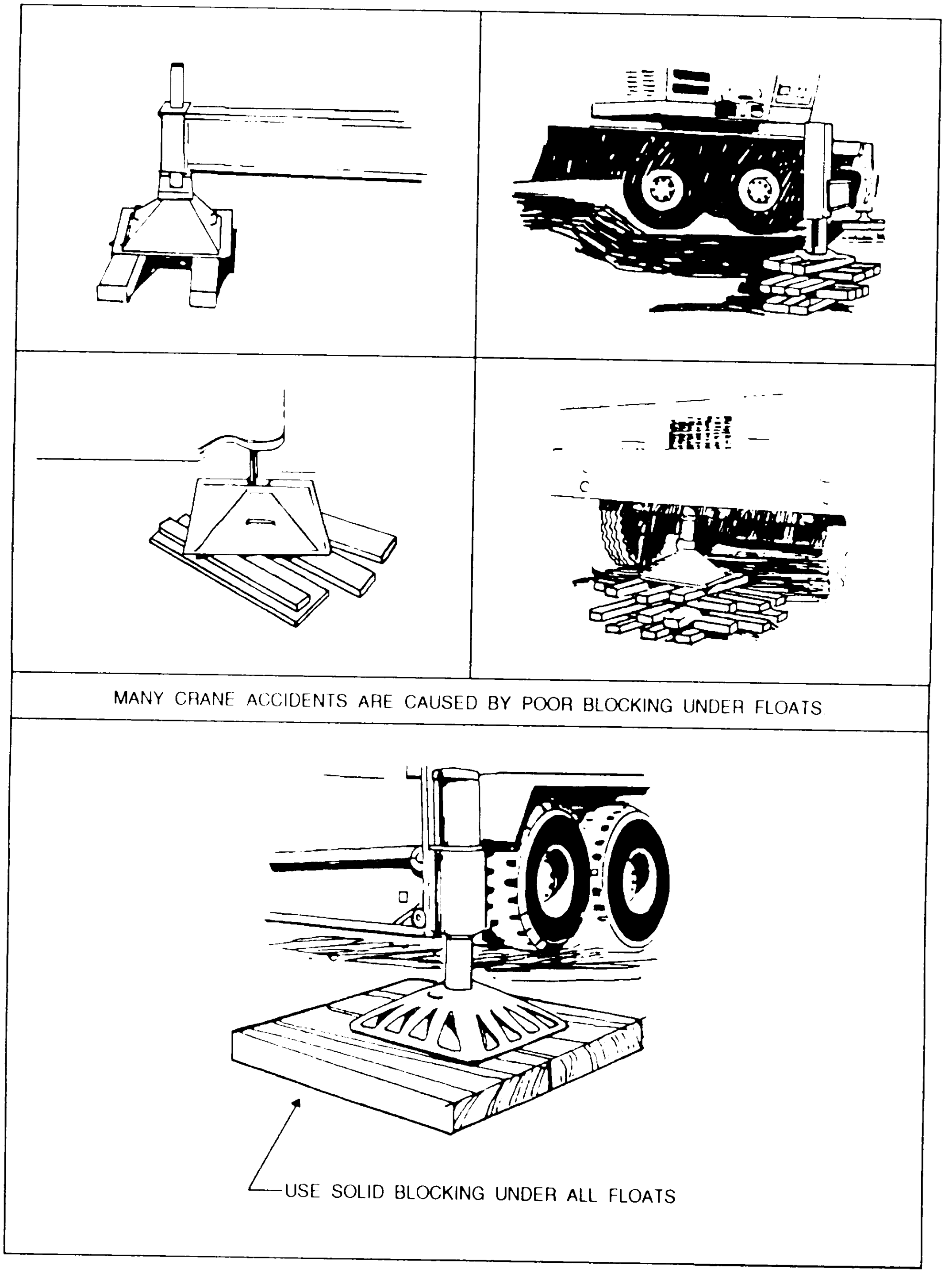

MANY CRANE ACCIDENTS ARE CAUSED BY POOR BLOCKING UNDER FLOATS.
USE SOLID BLOCKING UNDER ALL FLOATS

Figure 12-44.-Proper and improper cribbing.

Boom Length and Lift Radius	Chart Capacity Lost When Crane Out of Level By		
	1°	2°	3°
Short Boom, Minimum Radius	10%	20%	30%
Short Boom, Maximum Radius	8%	15%	20%
Long Boom, Minimum Radius	30%	41%	50%
Long Boom, Maximum Radius	5%	19%	15%

Figure 12-45.-Crane capacity lost by crane out of level.

1. Failure to block/crib under the outrigger pads when poor ground conditions cannot support the total weight of the crane and load. Proper and improper cribbing is shown in figure 12-44.

2. Failure to extend the outriggers fully and use them following the manufacturer's instruction.

3. Failure to note overhead obstructions, such as overpasses and power lines.

4. Failure to level the crane. Leveling the crane cannot be overemphasized. Cranes must be set up as per manufacturer's instruction with the outriggers fully extended and the crane leveled. Crane capacity is lost when the crane is out of level by only a few degrees (fig. 12-45). Most cranes have levels mounted on them, but the levels are not always accurate. Use a 3-foot builders level to check the level of the crane over the rear and over the sides (fig. 12-46).

Load Capacity

The rated capacities of mobile cranes are based on both **strength** and **stability.** Manufacturers of cranes will normally denote on the load charts a shaded area or a bold line across the chart dividing the lifting capacities based on strength or stability of the crane. It is extremely important to know the difference for, in one case, one of the structural components of the crane will break and, in the other case, the crane will tip over.

Additionally, the following factors must be recognized and the capacity adjusted accordingly:

1. Do not use stability to determine lifting capacity. Use the load chart installed by the crane manufacturer. The load chart is securely attached in the operator's cab.

2. The number of parts of line on the hoist and the size and type of wire rope for various crane loads.

3. Length of boom.

4. Boom angle.

5. Boom pendant angle (when the telescopic/ folding gantry is down, the angle decreases and the stress increases).

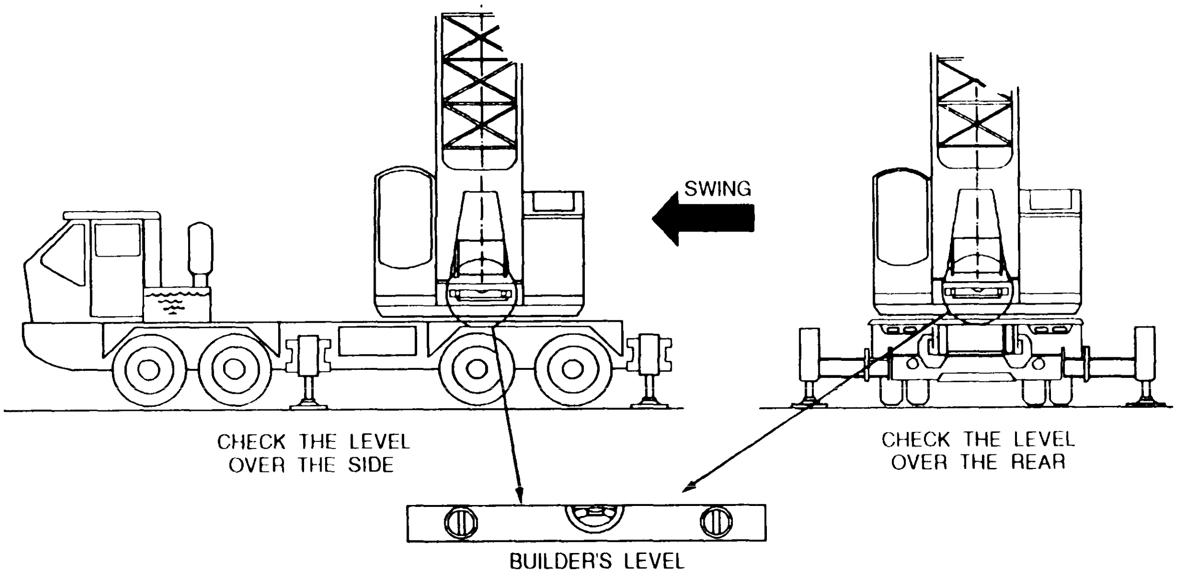


Figure 12-46.-Leveling procedures using a builder's level.

6. Gantry and/or live mast in the highest position.

7. Quadrant of operation (that is, over the side, over the rear capacities).

Load Rating Chart

Atypical load rating chart is shown in figure 12-47. To determine the capacity of the crane by using the load chart, the operator must know the length of boom, the load radius, the boom angle, and if the lift is to be performed over the side or over the rear.

When performing lifts using the boom angle indicator that indicates an angle not noted on the load chart, use the next lower boom angle noted on the load chart for determining the capacity of the crane. For example, using the load charts in figure 12-47, the crane is rigged with 60 feet of boom, and the boom angle indicator indicates a boom angle of 57 degrees. A 57-degree boom angle load capacity is not noted on the load chart, so you must use the next lower noted boom angle of 53 degrees for determining the capacity of the crane.

NOTE: Do not rely on the boom angle indicator for radius accuracy when lifts exceed 75 percent of the rated capacity. Measure the radius to avoid the possibility of error.

When using a radius measurement not noted on the load charts, use the next longer radius measurement noted on the load chart for determining the capacity of the crane. For example, using the load charts in figure 12-47, the crane is rigged with 50 feet of boom, and the radius measurement is 32 feet. A 32-foot radius measurement is not noted on the load charts, so you must use the next longer radius measurement of 35 feet noted on the load chart for determining the capacity of the crane.

The number of part lines reeved on the main hoist block can affect the capacity of the crane. If the crane is capable of being reeved with an eight-part line and the reeving is changed to a six-part line, the capacity of the crane changes. On newer models of cranes, the capacity for different parts of line configurations is noted on the load charts. On older models, you must refer to the manufacturer's manual.

The load chart provides the capacity of the crane with outriggers set and without outriggers. "Outriggers set" means the outriggers are fully extended and the weight of the crane is off of the suspension system or the tires are off the ground. If a situation arises where the outriggers cannot be fully extended, you must use the without outriggers load capacity ratings.

NOTE: Load capacities change when swinging from each quadrant of operation, such as from over the rear to over the side.

SAFE LIFTING

The following factors are basic guidelines to perform safe daily crane operations:

1. Determine the weight to be lifted and the crane required to make the lift safely.

2. Travel the proposed route the crane will follow to and from the project site, and complete the Crane Lift Checklist.

3. Obtain the travel permits if required.

4. Brief operators and riggers on the specifics of the lift and travel conditions.

5. Inspect the crane area setup for stability and safe operating area

6. Fully extend the outriggers and use them according to the manufacturer's instruction.

7. Check the crane for levelness.

8. Inspect all rigging hardware.

9. Select the proper sling with sufficient capacity rating.

10. Center the sling in the base (bowl) of the hook to avoid hook point loading, and ensure the hook block is always placed over the center of the load to eliminate shock loading of the slings or cranes, resulting from load shifts when a lift is made.

11. Make ample safety allowances for unknown factors.

12. Stand clear of and do not walk under suspended loads.

13. Boom deflection. All crane booms have deflection. When the load is lifted off the ground, the boom will deflect, causing the radius to increase. Increased radius may cause overloading of the crane.

14. An uncontrolled swinging load can cause the radius to increase.

15. Clean operating area. Water coolers, excess tools, grease, soda cans, and other unnecessary items should be kept outside of the operating area of the crane. Water coolers must be kept off the crane to prevent

MAXIMUM ALLOWABLE LOADS - CRANE SERVICE								
BOOM LENGTH IN FEET	LOAD RADIUS IN FEET	BOOM ANGLE IN DEGREES	BOOM POINT PIN HEIGHT	WITH OUTRIGGERS SET*		WITHOUT OUTRIGGERS		
				OVER SIDE	OVER REAR	OVER SIDE		OVER REAR
						8'-0" WIDE	9'-0" WIDE	9' OR 9' WIDE
30	10	78	35'6"	•50,000	•50,000	28,800	32,200	39,300
	12	74	35'0"	•50,000	•50,000	22,500	24,900	30,800
	15	68	34'0"	•50,000	•50,000	16,800	18,500	23,200
	20	57	31'3"	36,800	•43,700	11,700	12,800	16,200
	25	44	27'3"	26,000	31,100	8,800	9,700	12,400
40	12	78	45'3"	•50,000	•50,000	22,200	24,600	30,600
	15	74	44'6"	•50,000	•50,000	16,500	18,200	22,900
	20	66	42'9"	36,600	•41,300	11,400	12,500	16,000
	25	58	40'0"	25,800	30,900	8,600	9,400	12,200
	30	49	36'3"	19,800	23,700	6,800	7,400	9,700
	35	38	30'9"	15,900	19,100	5,500	6,050	8,000
50	15	77	55'0"	•50,000	•50,000	16,400	18,000	22,700
	20	71	53'6"	36,500	•40,000	11,300	12,300	15,800
	25	65	51'6"	25,700	•30,400	8,450	9,250	12,000
	30	58	48'9"	19,600	23,600	6,650	7,250	9,500
	35	51	45'0"	15,800	19,000	5,400	5,900	7,800
	40	43	40'6"	13,100	16,800	4,500	4,900	6,600
	45	34	34'0"	11,200	13,500	3,800	4,150	5,650
60	15	79	65'3"	•48,800	•48,800	16,100	17,800	22,500
	20	74	64'0"	36,400	•39,100	11,000	12,100	15,600
	25	69	62'3"	25,500	•29,600	8,150	8,950	11,800
	30	64	60'0"	19,500	23,400	6,350	7,000	9,300
	35	59	57'3"	15,600	18,800	5,100	5,650	7,600
	40	53	53'9"	13,000	15,700	4,200	4,650	6,400
	45	46	49'6"	11,000	13,300	3,500	3,900	5,350
	50	39	44'3"	9,500	11,600	2,950	3,300	4,700
	55	32	37'9"	8,400	10,200	2,500	2,800	4,000
70	20	77	74'3"	36,200	•37,300	10,700	11,800	15,400
	25	72	73'0"	25,300	•28,800	7,850	8,700	11,600
	30	68	71'0"	19,300	•23,100	6,100	6,700	9,100
	40	59	66'0"	12,800	15,500	3,900	4,350	6,200
	50	49	58'6"	9,350	11,400	2,700	3,000	4,500
	60	36	47'6"	7,200	8,850	1,850	2,150	3,350
80	20	78	84'6"	•32,800	•32,800			
	25	75	83'3"	23,200	•28,400			
	30	71	81'9"	19,100	•22,600			
	40	63	77'6"	12,600	15,300			
	50	55	71'3"	9,200	11,200			
	60	45	62'9"	7,050	8,700			
	70	34	50'9"	5,600	6,950			
90	20	80	94'9"	•29,000	•29,000			
	25	77	93'9"	25,100	•26,000			
	30	73	92'3"	19,000	•22,200			
	40	66	88'6"	12,500	15,200			
	50	59	83'3"	9,050	11,000			
	60	51	76'3"	6,900	8,550			
	70	43	66'9"	5,450	6,800			
	80	32	53'6"	4,400	5,600			
100	20	81	105'0"	•25,300	•25,300			
	30	75	102'9"	18,800	•20,500			
	40	69	99'3"	12,300	15,000			
	50	63	94'9"	8,850	10,800			
	60	56	88'9"	6,700	8,400			
	70	49	81'0"	5,250	6,600			
	80	40	70'6"	4,200	5,350			
	90	30	56'3"	3,350	4,400			
110	20	81	115'0"	•22,000	•22,000			
	30	76	113'0"	•17,700	•17,700			
	40	71	110'0"	12,100	•14,000			
	50	65	106'0"	8,650	10,700			
	60	59	100'6"	6,500	8,200			
	70	53	93'9"	5,050	6,450			
	80	46	85'3"	4,000	5,200			
	90	38	74'3"	3,200	4,250			
	100	29	59'0"	2,600	3,500			

Figure 12-47.-Typical crane capacity chart.

people from congregating around the crane when in operation.

NOTE: Safe lifting is paramount! Project completion must not interfere with safe crane operations.

CLAMSHELL OPERATIONS

The clamshell bucket is an attachment used with a crane for vertical digging belowground level and for placing materials at considerable height, depth, or distance. You can also use it for moving bulk materials from stockpiles to plant bins, loading hoppers, and conveyors. It can be used to dig loose to medium compacted soil.

Clamshell operating procedures are as follows:

1. Position and level the crane, ensuring the digging operation is as close to the radius as the dumping operation. This prevents you from having to boom up and down, resulting in a loss of production.

2. Select the correct size and type of bucket for the crane.

3. When lowering the clamshell bucket, if too much pressure is applied to the closing line brake, the bucket will close and an excess amount of wire rope will unwind from the holding line hoist drum. To avoid this, you should release the holding line and closing line brakes simultaneously when lowering the open clamshell into the material for the initial bite. Engage the closing line control lever to close the bucket. Control the digging depth by using the holding line control lever and brake.

4. If, during hoisting, the hoist line gets ahead of the closing line, the bucket will open and spill the material. (This could also be caused by having too much wire rope on the hoist drum.) The operator must hoist both the closing and holding lines at the same speed to keep the bucket from opening and spilling material.

5. When the clamshell bucket is raised enough to clear all obstacles, start the swing by engaging the swing control lever. Hoisting the bucket can be performed, as it is swung to the dumping site. The spring-loaded tag line will retard the twisting motion of the bucket if the swing is performed smoothly.

6. Dumping and unloading the clamshell is performed by keeping the holding line brake applied while the closing line brake is released. Apply the closing line brake quickly after the load is dumped to prevent the closing line from unwinding more wire rope than is needed to dump the material. After the bucket is emptied, swing the open clamshell back to the digging site. Then lower the open bucket and repeat the cycle.

The clamshell operating cycle has four steps: filling (closing) the bucket, raising the loaded bucket, swinging, and dumping. The boom angle for clamshell operations should be between 40 to 60 degrees. Be careful when working with higher boom angles, as the bucket could hit the boom. A clamshell attachment is not a positive digging tool.

The height reached by the clamshell depends on the length of the boom used. The depth reached by the clamshell is limited by the length of wire rope that the hoist drum can handle. For the safe lifting capacity for the clamshell, refer to the operator's manual and the crane capacity load chart.

DRAGLINE OPERATIONS

The dragline is a versatile attachment capable of a wide range of operations at and belowground level. The dragline can dig through loose to medium compacted soil. The biggest advantage of the dragline over other machines is its long reach for both digging and dumping. Another advantage is its high cycle speed. The dragline does not have the positive digging force of the backhoe. The bucket is not weighted or held in alignment by rigid structures; therefore, it can bounce, tip over, or drift sideways when digging through hard materials. This weakness increases with digging depth.

Dragline operating procedures are as follows:

1. Keep the teeth sharp of the dragline bucket and built up to proper size.

2. Keep the dump rope short, so the load can be picked up at a proper distance from the crane.

3. Excavate the working area in layers, not in trenches, and sloped upward toward the crane.

4. Do not drag the bucket in so close to the crane that it builds piles and ridges of material in front of the crane.

5. Do not guide the bucket by swinging the crane while digging. This puts unnecessary side stresses on the boom. Start the swing only after the bucket has been raised clear of the ground.

6. A pair of drag chains is attached to the front of the bucket through brackets by which the pull point may be adjusted up or down. The upper position is used for deep or hard digging, as it pulls the teeth into a steeper angle.

7. The drag cable can be reversed end for end to prolong the life of the wire rope, reduce early wire rope replacement, and keep wire rope cost down. Remember, the drag cable should not be lubricated.

8. When lowering the dragline bucket into the area to be worked, release the drag brake to tip the cutting edge down and then release the hoist brake. You do not have to drop the bucket to force the teeth into the material. The bucket is filled as it is dragged toward the crane by engaging the drag control lever. The cutting depth is controlled by releasing tension from the hoist brake. The dragline is NOT a positive digging tool.

9. The dragline cycle is filling the bucket, lifting the bucket, swinging the loaded bucket, and dumping the load.

10. Since the dragline is not a rigid attachment, it will not dump materials as accurately as do other excavators. When a load is dumped into a haul unit or hopper, you need more time to position the bucket before dumping it.

NOTE: When you are dumping into a haul unit, NEVER load over the cab. Additionally, make sure the operator is out of the cab and clear of the dragline or clamshell bucket.

11. The boom angle for dragline operations should normally be from 25 to 35 degrees. However, check the crane load chart to ensure this low boom angle does not exceed the capacity of the crane. At this relatively low boom angle, you must be careful when excavating and dumping wet, sticky materials, because the chance of tipping the crane is increased because the material tends to hang in the bucket.

Dragline Employment

The dragline can be used in dredging where the material handled is wet and sticky. It can dig trenches, strip overburden, clean and dig road side ditches, and slope embankments. When the dragline is handling mud, it is the most practical attachment. Its reach enables it to handle a wide area of excavation while sitting in one position, and the sliding action of the bucket eliminates trouble with suction.

Other uses of the dragline include the following:

1. In-line approach. When excavating a trench with the dragline, ensure the dragline and carrier unit are centered on the excavation (fig. 12-48). The dragline cuts or digs to the front and dumps on either side of the excavation. The crane moves away from the face as the work progresses.

2. Parallel approach. The dragline can slope an embankment better by working it from the bottom to the top. The crane is positioned on the top with the carrier parallel to the working face, so it can move the full length of the job without excessive turning.

3. Drainage. A dragline is ideal if earthwork materials have to be removed from a trench, canal, gravel pit, and so forth, containing water. Plan the work to begin at the lowest grade point, so drainage will be provided as the dragline progresses towards higher levels.

NOTE: Digging underwater or in wet materials increase the weight of the materials and frequently prevent carrying heaped bucket loads.

Ditching the excavation through swamps or soft terrain is common. Under these conditions the excavated material is normally cast onto a levee or spoils bank.

4. Loading haul units. When the job requires excavated material to be loaded into hauling units, the excavation should be opened up so loaded hauling equipment can travel on high, dry ground or on better grades. The spotting of trucks and dragline should be planned for minimum boom swing with the truck bed under the boom point and the long axis of the bed parallel with the long axis of the boom or at right angles to the boom. More spillage is to be expected from a dragline than from a front-end loader.

Efficient Dragline Operation

Other uses of the dragline operation include the following:

1. Although the dragline bucket can be readily cast beyond the length of the boom, the machine should be positioned to eliminate casting.

2. Use heavy timber mats for work on soft ground. The mats should be kept level and clean.

3. When setting up for a dragline operation, you should have access for maintenance, operating personnel, and hauling equipment.

4. Excavate the working area in layers, not in trenches, and keep the slope upward toward the crane.

5. Do not drag the bucket in so close to the crane that it builds piles and ridges of material in front of the crane.

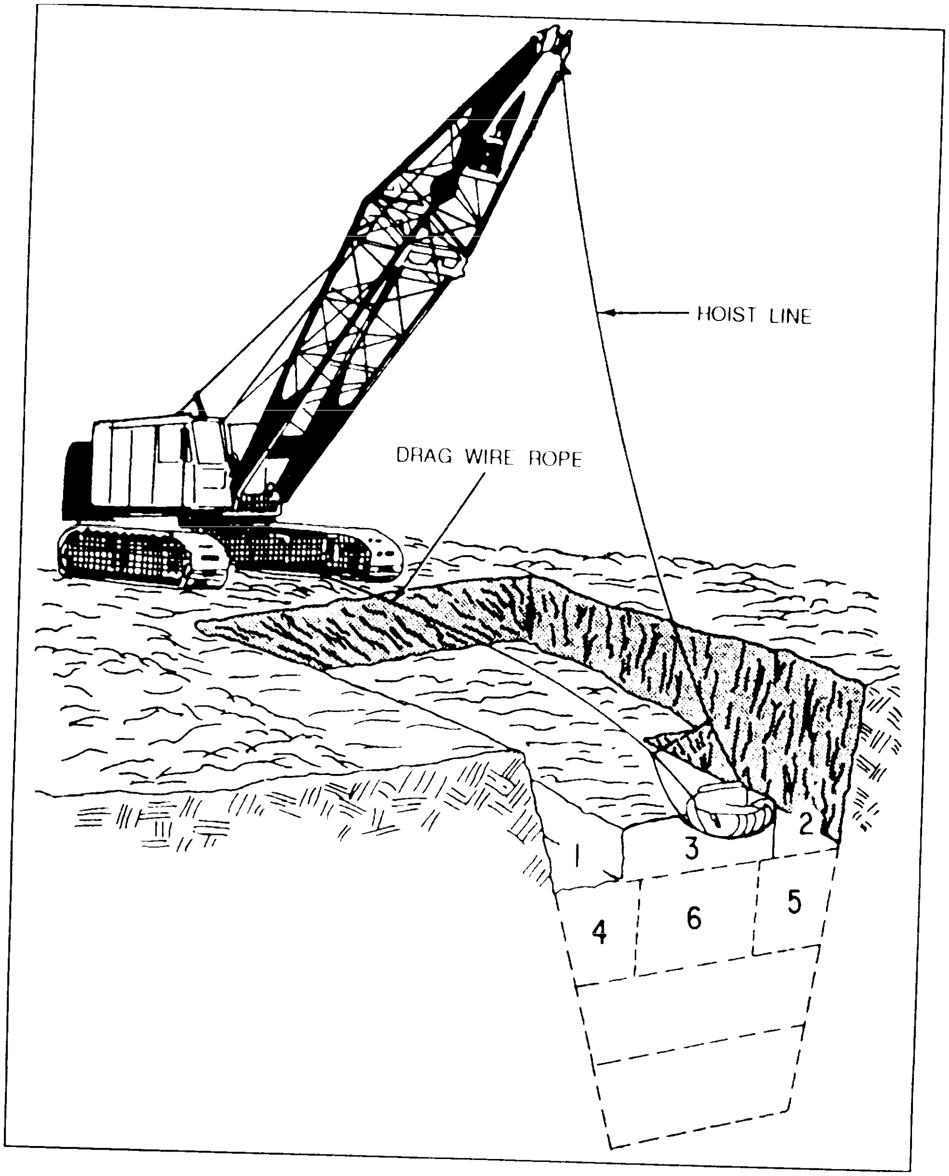


Figure 12-48.-In-line approach with dragline.

6. Salvage pieces of hoist wire rope for use as the dump rope.

PILE-DRIVING OPERATIONS

Pile driving in the NCF is done with crawler- or truck-mounted cranes rigged with pile-driving attachments, as shown in figure 12-49. The pile-driving hammer is categorized under the 36-00000 USN number registration series.

NOTE: The combined weight of all the pile-driving attachments reduces the capacity of the crane. Additionally, the crane capacity must be able to support the combined weight of all of the pile-driving attachments.

LEADS

Pile-driving leads serve as tracks along which the pile-driving hammer runs and as guides for positioning and steadying the pile during driving operations. The leads come in 10-, 15-, and 20-foot sections bolted together to form various lengths, as shown in figure 12-50.

NOTE: Because of the vibrations created during pile-driving operations, you must check all the lead

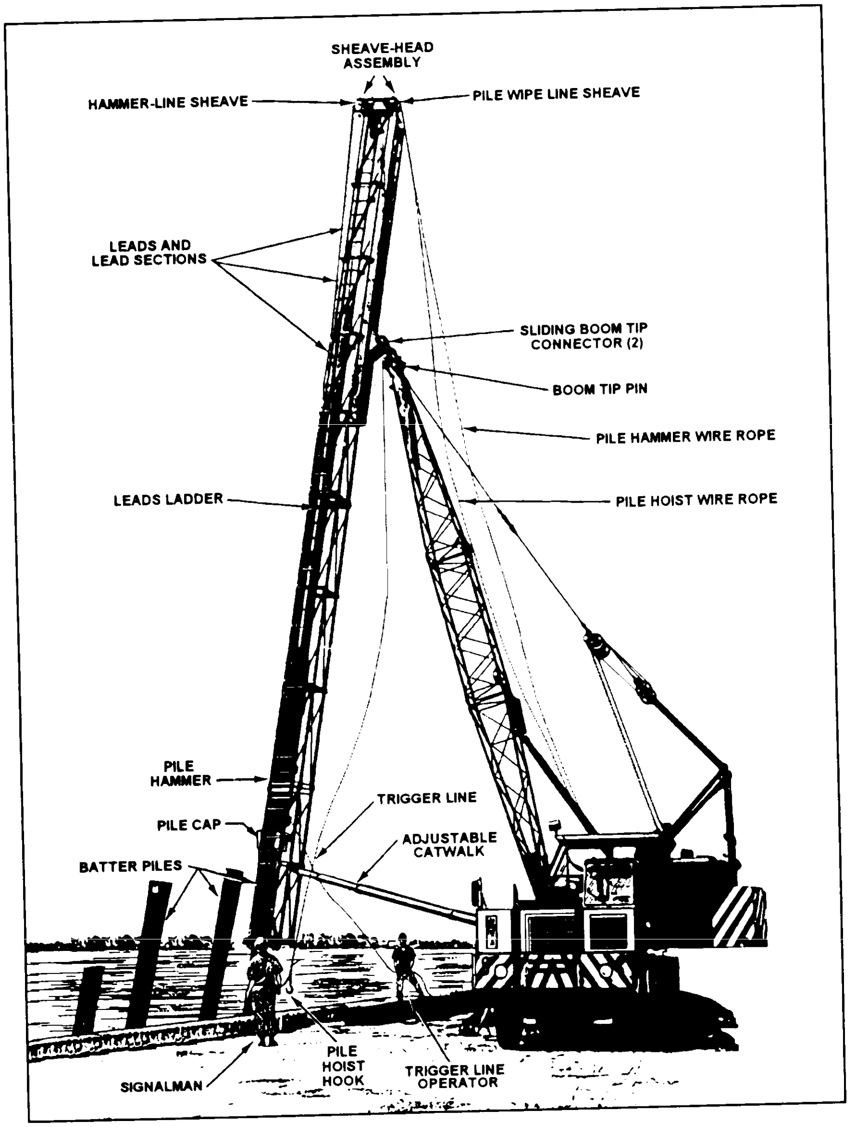

SHEAVE-HEAD ASSEMBLY
HAMMER-LINE SHEAVE
PILE WIPE LINE SHEAVE
LEADS AND LEAD SECTIONS
SLIDING BOOM TIP CONNECTOR (2)
BOOM TIP PIN
PILE HAMMER WIRE ROPE
LEADS LADDER
PILE HOIST WIRE ROPE
PILE HAMMER
TRIGGER LINE
PILE CAP
ADJUSTABLE CATWALK
BATTER PILES
PILE HOIST HOOK
TRIGGER LINE OPERATOR
SIGNALMAN

Figure 12-49.—Typical pile-driving operation.

section bolts for tightness at the beginning of each pile-driving shift.

The types of leads used in the NCF are swinging, underhung, extended four-way, and spud leads.

Swinging Leads

Swinging leads are assembled facedown on the ground by bolting the 15-foot tapered section to the selected intermediate sections. A single crane line holds the pile-driving hammer that is slipped into and guided by the rails of the swinging leads. This lead is hung from the crane boom with a second single line from the crane. The lead is spotted on the ground at the pile location, normally with stabbing points attached to the bottom of the leads, and held plumb or at the desired batter with the second single crane line. Short swinging leads are often used to assist in driving

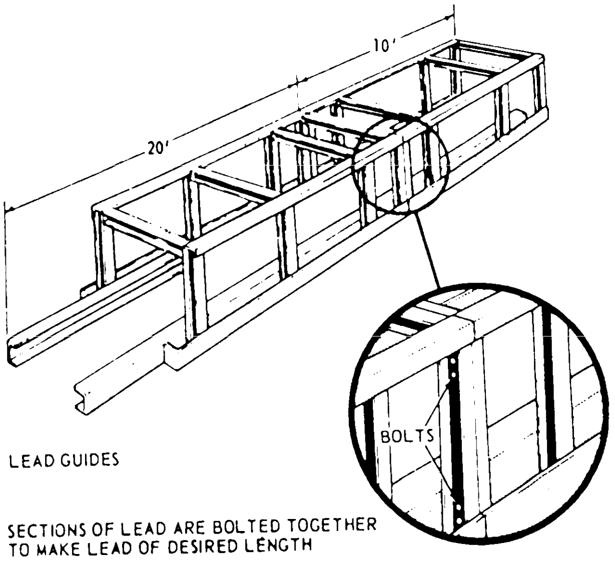

10'
20'
BOLTS
LEAD GUIDES
SECTIONS OF LEAD ARE BOLTED TOGETHER TO MAKE LEAD OF DESIRED LENGTH

Figure 12-50.-Assembly of 10- and 20-foot lead sections.

steel sheetpilings. Figure 12-51 shows the components of a swinging lead.

The boom point sheaves are used to accommodate the hoist drum wire rope that supports the pile, pile-driving hammer, and leads; therefore, its use requires a three-drum crane. Under certain conditions a two-drum crane can be used The leads are raised to the vertical by a combination of booming, swinging, and/or traveling.

ADVANTAGES.— Some advantages of using a swinging lead over other types of leads are as follows:

1. They are the lightest, simplest, and least expensive.

2. With stabbing points secured in the ground, these leads are free to rotate sufficiently to align the pile-driving hammer with the pile without precise alignment of the crane with the pile.

3. Because these leads are generally 15 to 20 feet shorter than the boom, the crane can reach out farther if the crane has sufficient capacity.

4. They can be used to drive piles in a hole, ditch, or over the edge of an excavation.

5. For long lead and boom requirements, the weight of the leads can be supported on the ground and the pile is lifted into place without excessively increasing the working load weight.

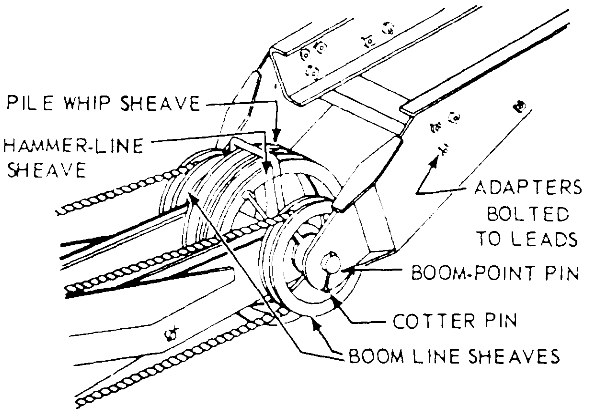


Figure 12-52.-Lead adapters connected to the boom tip.

DISADVANTAGES.— Some disadvantages of using a swinging lead are as follows:

1. It requires a three-hoist drum crane (main line for the pile, secondary for the pile-driving hammer, and third for the leads) or two-hoist drum crane with the lead hung on the sling from the boom tip.

2. Because the leads are supported by the hoist wire rope, precise positioning of the leads with the top of the pile is difficult and slow.

3. If stabbing points are not secured to the ground, it is difficult to control the twisting of the leads.

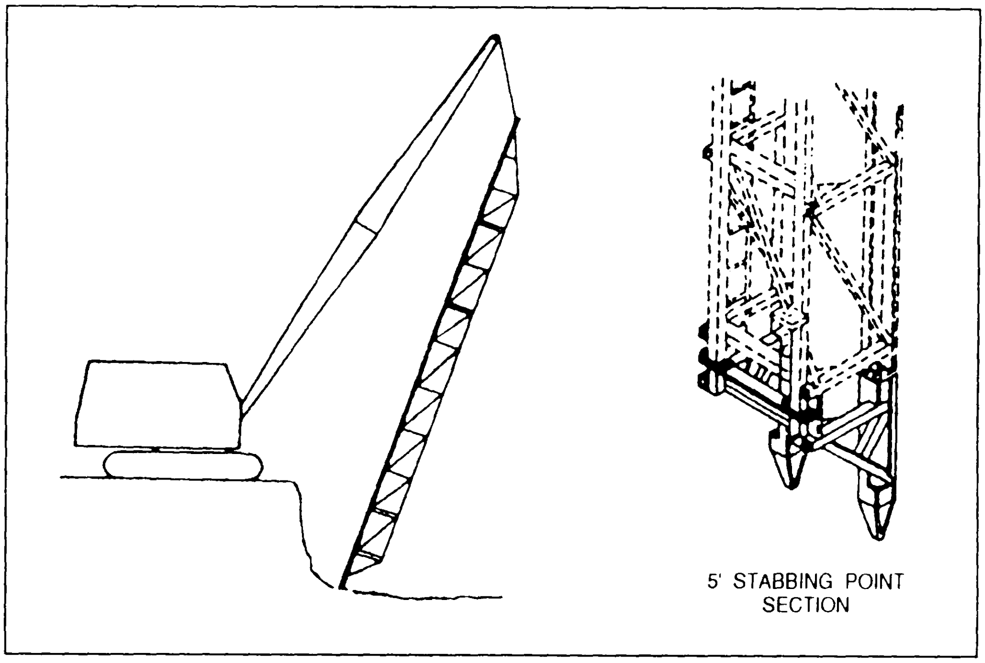


Figure 12-51.-Swinging leads.

NOTE: The tag line winder may be used to control the twisting of the leads.

4. Because these leads are not rigid, it is more difficult to position the crane to set up for pile-driving operations.

Underhung Leads

Underhung leads are composed of exactly the same sections used for swinging leads. Underhung leads are bolted together on the ground, as described for swinging leads, and connected to the boom tip through the use of lead adapters (fig. 12-52). The boom tip sheaves are used to accommodate the pile and the pile-driving hammer. All underhung leads have a standard bolt hole layout for bolting the lead adapters to the leads; however, the dimensions of the boom tip end of the adapters vary according to the make and model of the crane. After the adapters are connected to the boom, the boom is raised to bring the leads to a vertical position (fig. 12-53). Long lead sections may require the use of support equipment to raise the leads to a vertical position.

NOTE: Check the adapter bolts for tightness at the beginning of each pile-driving shift.

Adapter plates are mounted to the boom butt or crane cab and on the bottom lead section for connection of a fore-and-aft bottom brace, commonly known as a **catwalk.** The catwalk can be extended or telescoped to various lengths. It can be set to hold the leads vertical for driving bearing piles or to hold them at an angle for driving batter piles. In use, an underhung lead is held by the boom at a fixed radius (fig. 12-54).

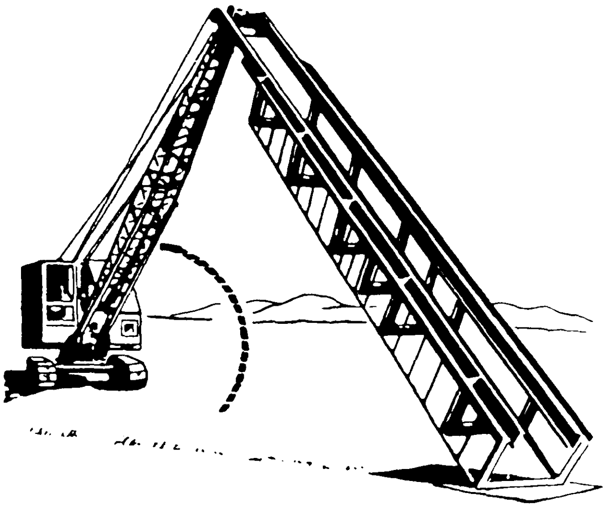


Figure 12-53.-Underhung leads being raised by the boom.

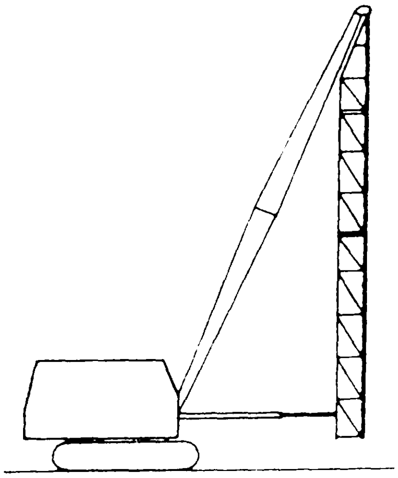


Figure 12-54.-Underhung leads.

ADVANTAGES.— Some advantages of using underhung leads over other types of leads areas follows:

1. They are lighter and generally less expensive than the extended four-way type of lead.

2. They require only a two-hoist drum crane.

3. They provide accuracy in positioning leads in vertical and fore-and-aft batter positions.

4. They provide precise control of the leads during positioning operation.

5. They reduce rigging time in setting up and breaking down.

6. They use boom tip sheaves.

DISADVANTAGES.— Some disadvantages of using underhung leads are as follows:

1. They cannot be used for side-to-side batter driving.

2. The length of pile is limited by boom length, since this type of lead cannot be extended above the boom tip.

3. When long leads require the use of long boom lengths, the working radius that results may be excessive for the capacity of the crane.

4. They do not allow the use of a boom shorter than the lead.

Extended Four-Way Leads

Extended four-way leads use the same intermediate lead sections as swinging and underhung leads. In place of a 15-foot tapered section, an extended lead uses a

30-foot slide section with a sheave head **assembly.** A universal **sliding boom tip connector,** slipped into the 30-foot slide section, connects to the boom tip (fig. 12-55). The sliding boom tip connector swivels, allowing for driving batter piles in all directions.

The boom is lowered over the leads when connecting the boom tip to the sliding boom connector. The connector is bolted into the 30-foot slide section at the location dictated by the amount of lead extension desired above the boom tip.

NOTE: Extension of the lead over the boom tip must not exceed one third of the total lead length or up to 25 feet maximum.

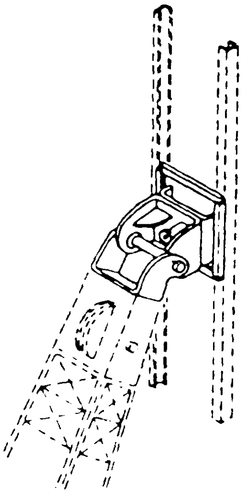


Figure 12-55.-Sliding boom tip connector.

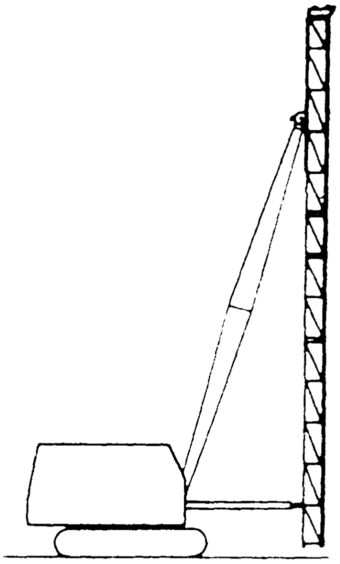


Figure 12-56.-Extended four-way lead.

The boom is raised to raise the leads. The type of catwalk used is a hydraulic or mechanical **parallelogram bottom brace.** This type of brace allows for a fixed radius or side-to-side batter by swinging the linked parallelogram in the desired position. The parallelogram allows for pile driving in all directions at the bottom. Figure 12-56 shows an extended four-way lead.

The boom point sheaves are not used to accommodate the pile-driving hammer and the piles. The extended four-way leads are equipped with a special **sheave head assembly** (fig. 12-57) that the two-hoist drum wire rope reeves through to support the pile-driving hammer and the piles.

ADVANTAGES.— Some advantages of using an extended four-way lead are as follows:

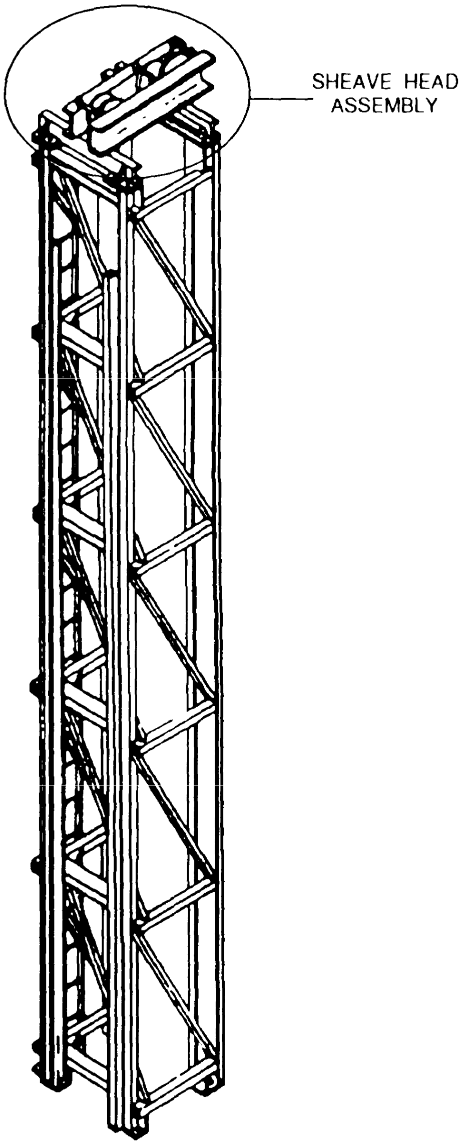


Figure 12-57.-Sheave head assembly.

1. It requires only a two-hoist drum crane.

2. It provides accuracy in locating leads in all batter positions.

3. It provides rigid control of the leads during positioning operation.

4. It allows batter angles to be set and accurately maintained.

5. It allows for the use of short boom angles that increases the crane capacity.

6. The boom can be lowered and leads folded under for short hauls over the road when a crane with adequate capacity is used This operation depends on the length of the lead and boom and the configuration of the crane.

DISADVANTAGES.— Some disadvantages of using an extended four-way lead are as follows:

1. It is the heaviest and most expensive of the three basic lead types.

2. It is more troublesome to assemble.

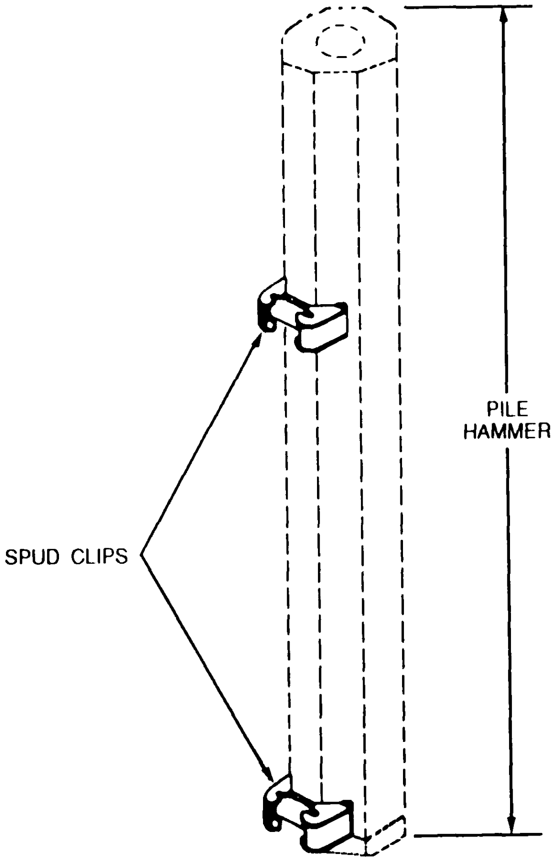


Figure 12-58.-Spud clips mounted to one side of the pile-driving hammer.

Spud Leads

A spud lead is a steel wide flange or H-beam used in place of pile-driving hammer leads. The pile-driving hammer rides on the flange of the beam through spud clips bolted to one side of the pile-driving hammer (fig. 12-58).

Depending on the design of the spud lead, the spud can be used as a swinging and underhung lead or equipped with a sheave head assembly as an extended four-way lead An advantage of this type of lead is that it bears the whole bottom of the pile cap to the piling especially when sheetpiling is being driven (fig. 12-59).

PILE-DRIVING HAMMERS

The three principal types of pile-driving hammers are the **drop hammer,** the **steam,** or **pneumatic, hammer,** and the **diesel hammer.**

A drop hammer is a block of metal hoisted to a specific height and then dropped on a cap paced on the butt or head of the pile. Drop hammers weigh from 1,200 to 3,000 pounds.

WARNING

The noise generated by a pile driving operation can cause hearing loss. Hearing protection must be worn by personnel in the vicinity of pile driving operations.

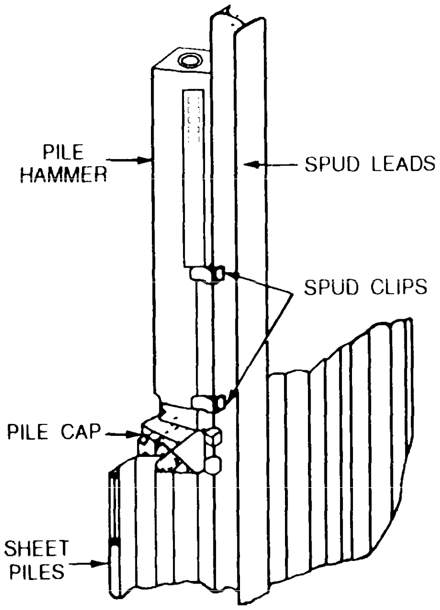


Figure 12-59.-Sheet pile driving with spud leads.

The steam, or pneumatic, hammer has basically replaced the drop hammer. This hammer (fig. 12-60) consists of a cylinder that contains a steam-driven or air-driven **ram.** The ram consists of a **piston** equipped with a **striking head.** The hammer is rested on the butt or head of the pile for driving.

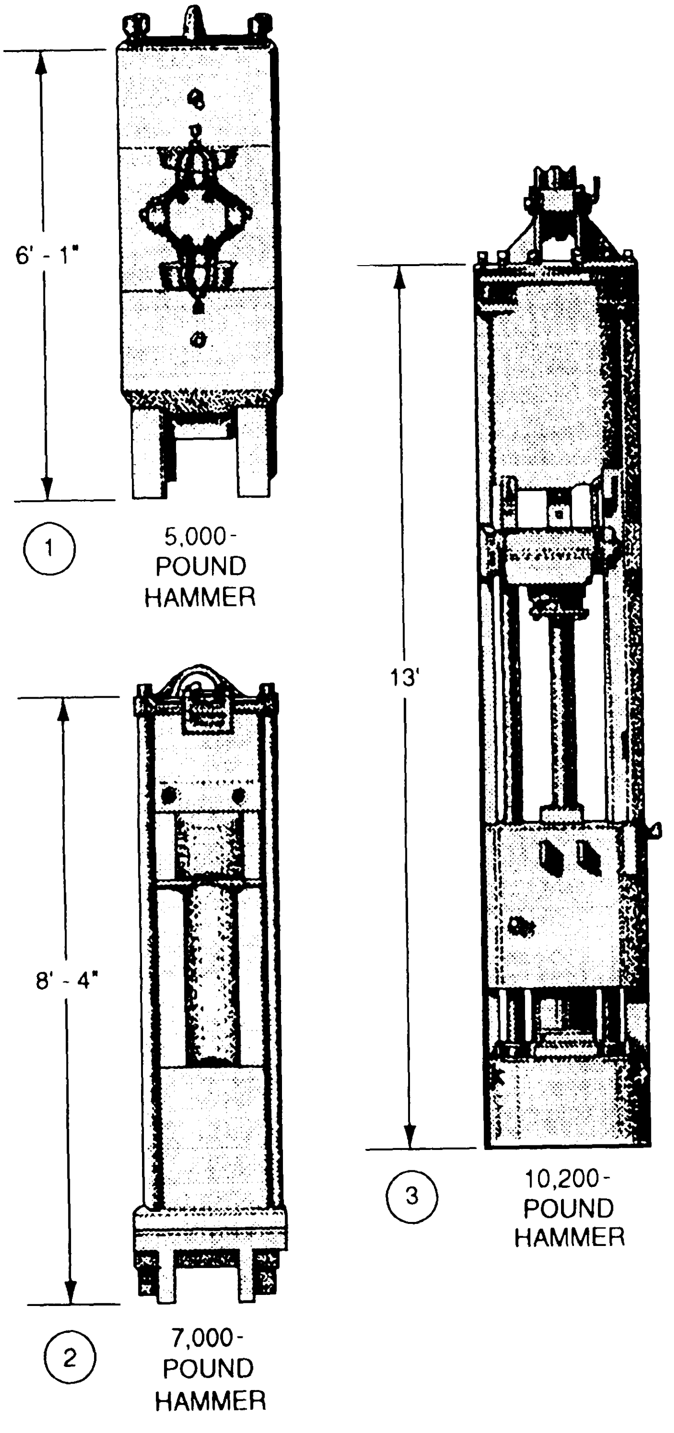


Figure 12-60.— Steam, or pneumatic, pile hammer.

With a **single-action** steam, or pneumatic, hammer, the power drive serves only to lift the ram; the downward blow of the ram results from the force of gravity only. In a **double-action** hammer, the ram is both lifted and driven downward by the power drive. A double-action hammer weighs from 5,000 to 14,000 pounds, and a single-action hammer weighs about 10,000 pounds.

The blows of the double-action hammer are lighter, but more rapid than those of the single-action hammer. The double-action hammer generally drives lightweight or average weight piles into soils of average density. The rapid blows tend to keep the pile in motion, thereby reducing the resistance of inertia and friction. However, when you are driving heavy piles in hard or dense soil, the resistance from inertia and friction, together with the rapid, high-velocity blows of the double-action hammer, tends to damage the butt or head of the pile.

The single-action hammer is best for driving heavy piles into hard or dense soil. The heavy ram, striking at low velocity, allows more energy to be transferred into the motion of the pile, thereby reducing impact and damage to the butt or head of the pile.

A conventional pneumatic hammer requires a 600-cubic-foot-per-minute compressor to operate, and the diesel is a self-contained unit constructed in sizes that deliver up to 43,000 foot-pounds of energy per blow. The diesel pile hammer is about twice as fast as a conventional pneumatic, or steam, hammer of like size and weight.

Diesel Hammer Operation

The most common diesel hammer used in the NCF is the DE-10 McKiernan-Terry pile hammer shown in figure 12-61. The hammer is lifted and started by a single crane load line connected to a **trip mechanism** (A). The hammer is started by lifting the ram piston (B) with the load line until the trip mechanism (C) automatically releases the ram piston. The ram piston falls and actuates the cam of the fuel pump (D) that delivers a measured amount of diesel fuel that falls into a cup formed in the top of the anvil (E). Continuing its downfall, the ram piston blocks the exhaust ports (F) and begins compression of air trapped between the ram piston and the anvil. The compression of the trapped air creates a preloading force upon the anvil, the drive cap, and the pile. The gravity propelled ram piston strikes the anvil, delivering its impact energy to the pile.

The rounded end of the ram piston mates perfectly with the cup in the anvil and displaces the fuel at the

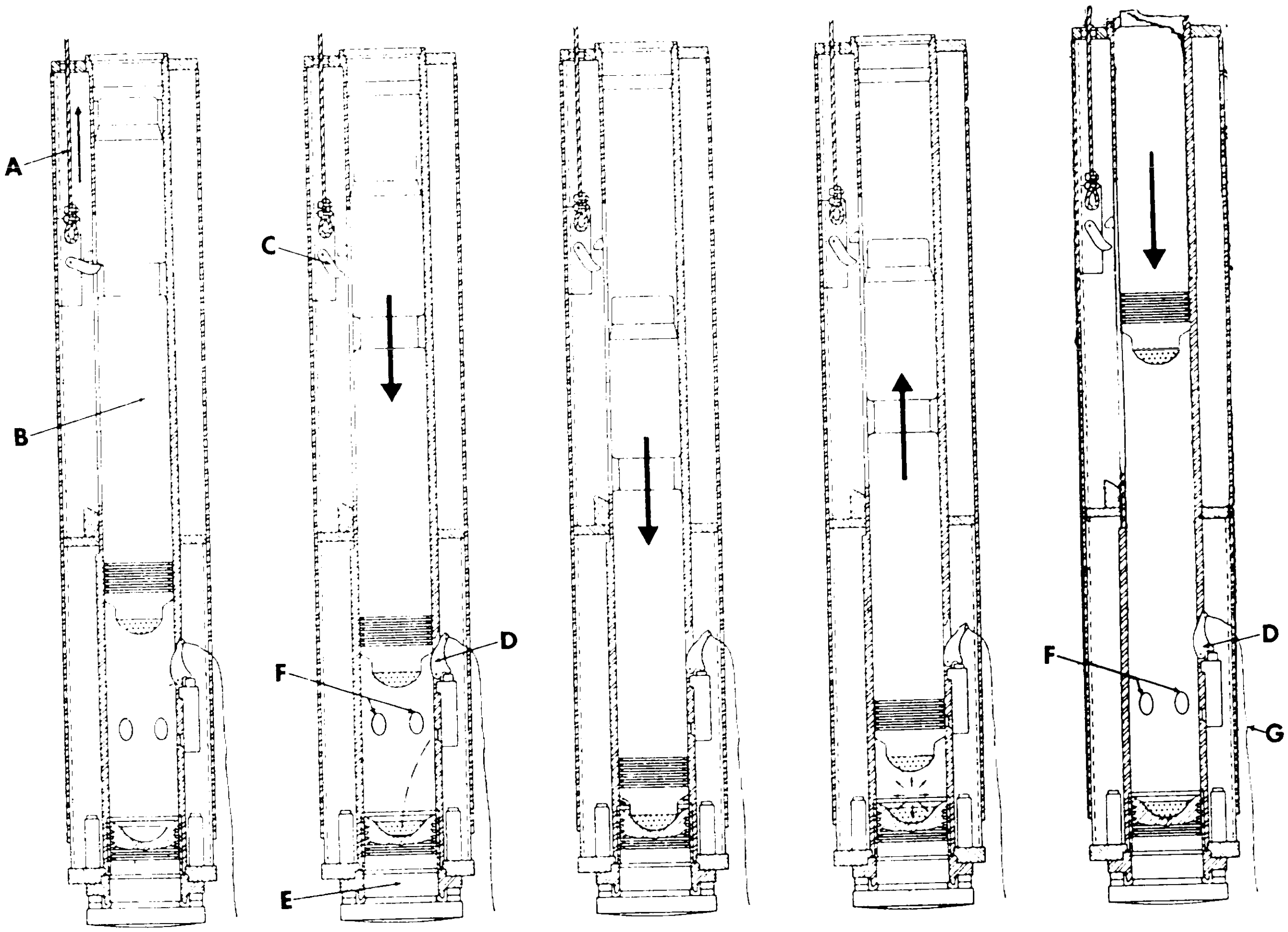


Figure 12-61.-Operating principles of the McKiernan-Terry diesel pile hammer.

precise moment of impact for perfect timing. The fuel is atomized and splattered into the annular (ring-shaped) zone between the ram and the anvil and is ignited by the heat of compression.

The resulting explosive force drives the ram piston upward and the pile downward and adds a push to the pile to extend the time of the total effort to drive the pile.

On the upstroke, the ram piston opens the exhaust ports (F) to permit scavenging the exhaust gases. The ram piston continues freely upward until arrested by gravity. The length of the stroke varies with the resistance of the pile. The greater the resistance, the longer the stroke.

Having reached the top of its stroke, the ram piston falls again, repeating the cycle. The hammer is stopped by pulling a rope (G) that disengages the fuel pump cam (D).

TRIP MECHANISM.— The trip mechanism (fig. 12-62) is an off-center linkage mechanism located at the rear of the hammer, designed to lift and drop the ram for starting. Additionally, the trip mechanism lifts and lowers the hammer in the leads. The trip mechanism is connected to a single line from the crane. Lowering the trip mechanism to the bottom of its stroke engages the lifting lever that lifts the ram. When the crane lifts the trip mechanism and ram piston past the upper stops, the finger of the trip lever is rotated clockwise around the trip lever pin, thus freeing the ram piston. The trip mechanism is held in the upper position while the hammer is in operation.

The safety link in the trip mechanism is designed to break or bend should the operator lower the trip mechanism to low and engage the lifting lever while the hammer is in operation. The safety link prevents damaging the trip mechanism or ram. If the safety link is broken while the hammer is in operation, the hammer will continue to operate; however, once the hammer is shut down, the safety link must be replaced before the hammer can be restarted.

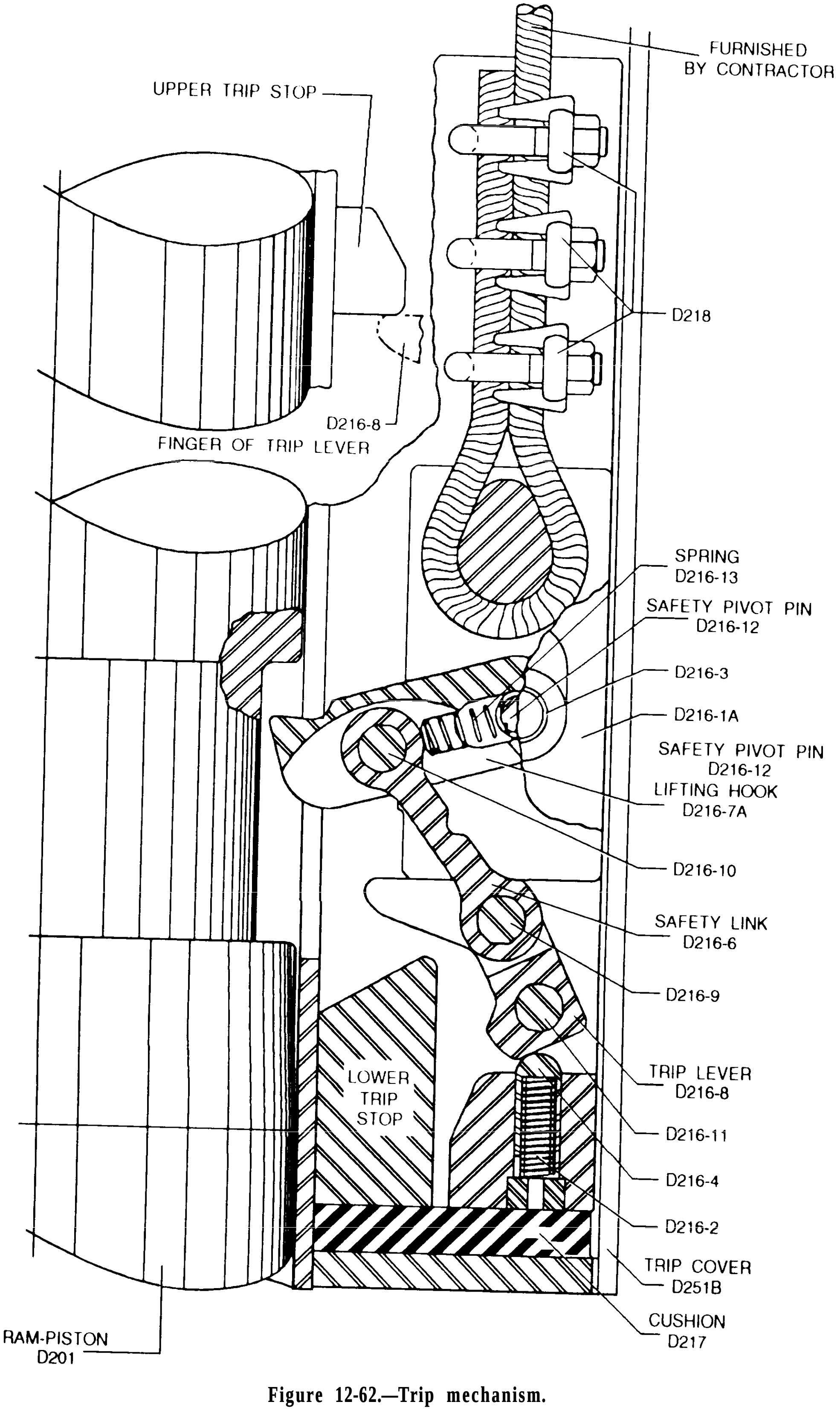

FURNISHED BY CONTRACTOR
UPPER TRIP STOP
D218
D216-8
FINGER OF TRIP LEVER
SPRING D216-13
SAFETY PIVOT PIN D216-12
D216-3
D216-1A
SAFETY PIVOT PIN D216-12
LIFTING HOOK D216-7A
D216-10
SAFETY LINK D216-6
D216-9
LOWER TRIP STOP
TRIP LEVER D216-8
D216-11
D216-4
D216-2
TRIP COVER D251B
CUSHION D217
RAM-PISTON D201

Figure 12-62.—Trip mechanism.

NOTE: The number of safety links to have on hand depends on the experience of the crane operator; however, as a rule of thumb you should have at lease 5 to 10 safety links stored in the toolbox on the jobsite.

FUEL SYSTEM.— Diesel or kerosene fuel is fed by gravity from the main fuel tank through the filter cartridge and in-line shut-off valve and down the inlet line to the pump. The cam-actuated fuel pump is located at the lower end of the cylinder and injects the fuel directly into the combustion chamber in the anvil. The hammer usually consumes about .9 gallon of fuel per hour of operation, and the capacity of the tank is 9 gallons.

LUBRICATION SYSTEM.— Oil drains are fed by gravity from the lubrication tank (fig. 12-63) through the wire mesh falter and in-line shut-off valve down the inlet line to the reservoir in the pump baseplate. From the reservoir oil feeds through passages in the pump to

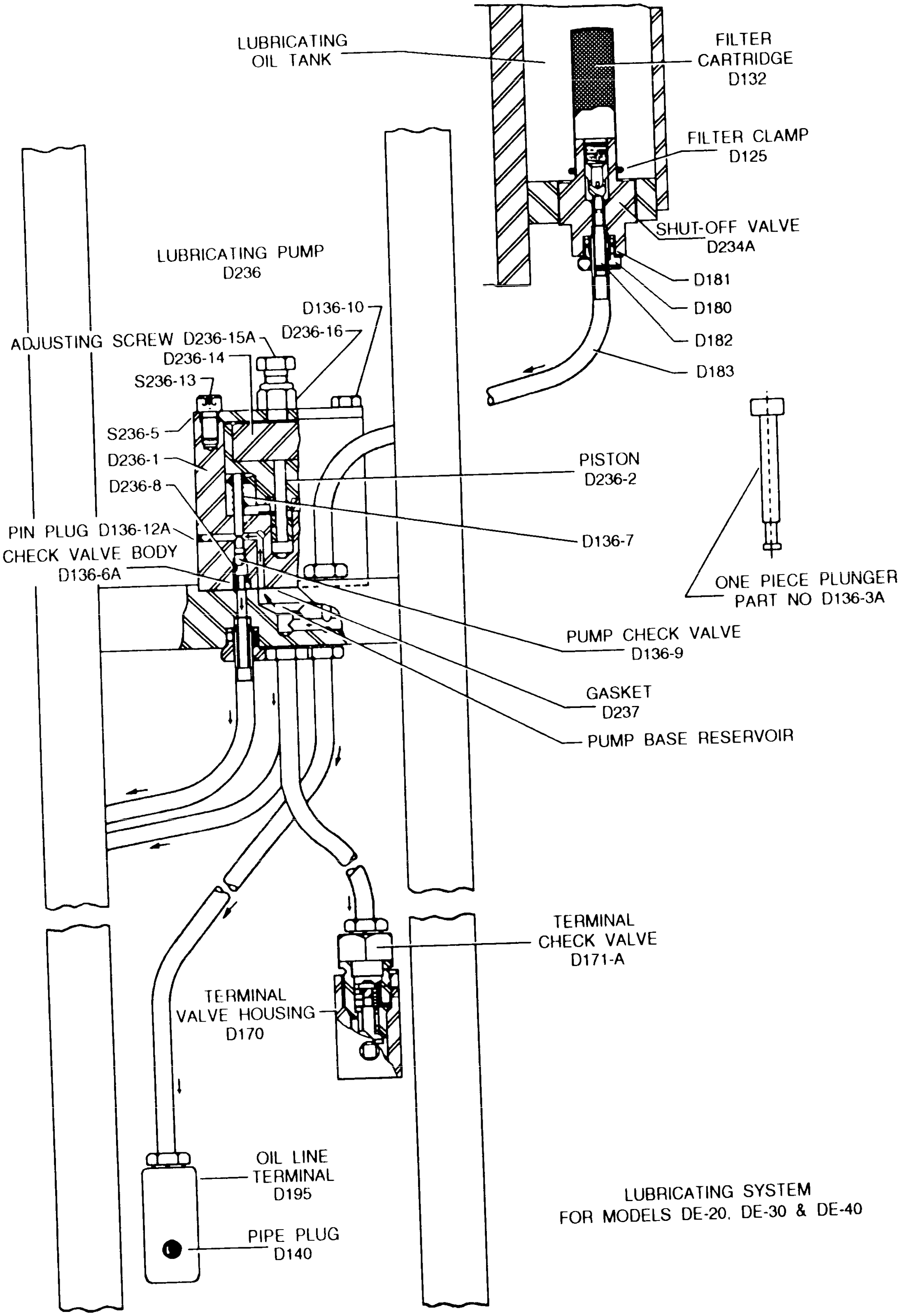

LUBRICATING OIL TANK
FILTER CARTRIDGE D132
FILTER CLAMP D125
SHUT-OFF VALVE D234A
D181
D180
D182
D183
LUBRICATING PUMP D236
D136-10
D236-16
ADJUSTING SCREW D236-15A
D236-14
S236-13
S236-5
D236-1
D236-8
PIN PLUG D136-12A
CHECK VALVE BODY D136-6A
PISTON D236-2
D136-7
ONE PIECE PLUNGER PART NO D136-3A
PUMP CHECK VALVE D136-9
GASKET D237
PUMP BASE RESERVOIR
TERMINAL CHECK VALVE D171-A
TERMINAL VALVE HOUSING D170
OIL LINE TERMINAL D195
PIPE PLUG D140
LUBRICATING SYSTEM FOR MODELS DE-20, DE-30 & DE-40

Figure 12-63.-Lubrication system.

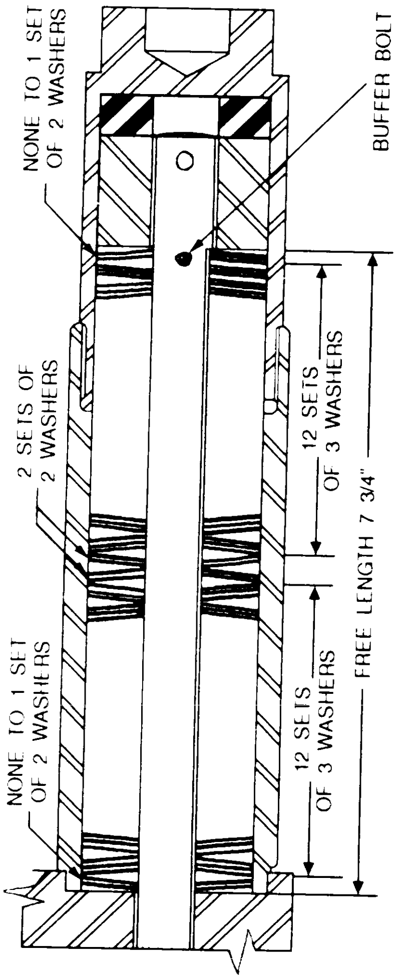


Figure 12-64.-Buffer bolt.

small plungers. A weighted piston rests on these plungers. Ajar of the hammer while in operation forces the piston and plunger down and thus drives a small amount of oil past the ball check valves and into the feed lines. Two of the feed lines have terminal checks that hold back the high pressure of the combustion chamber. A small pipe plug is provided at each terminal to observe the flow of oil.

NOTE: Fill the oil reservoir with **high temperature,** high detergent No. 30 to No. 40 viscosity diesel engine lubricating oil with a flash point of 425° to 450°.

CYLINDER.— The cylinder is a stress-relieved weldment made from steel tubing and plate with a bore specifically chrome-plated to prevent seizing, galling, and rapid wear. The shape of the shell forms a fuel and oil tank as well as protection for the fuel and oil pumps, lines, and trip mechanism. Cover plates, front and back provide easy access to the components. For safety in transporting and rigging the hammer, the ram piston is locked in place by a travel plug found midway on the front of the hammer. This plug should be removed when the hammer is rigged and ready for operation and should be replaced when the hammer is removed from the leads or is laid horizontal. The ram piston is a chrome-steel forging that has eight compression rings.

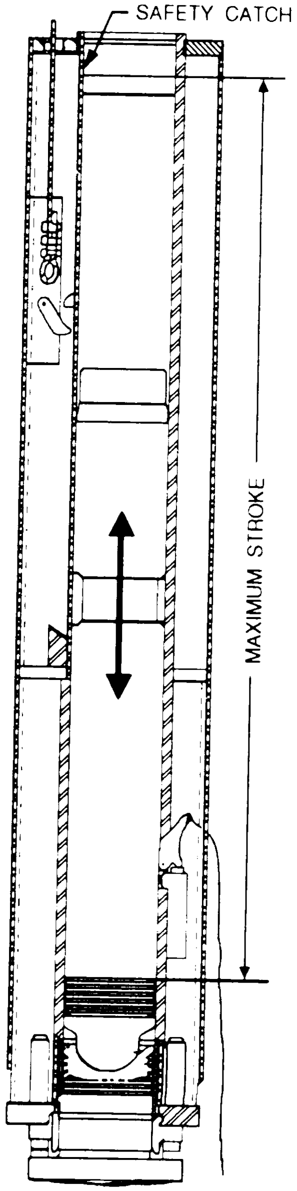


Figure 12-65.-Maximum ram-piston overstroke.

BASE ASSEMBLY.—The anvil block in the base assembly group is held in place by buffer bolts and has compression rings identical to those on the ram piston (fig. 12-64). Radial thrust or side thrust to the hammer is transmitted to the leads through the thrust bearing. A vibration damper, concealed under a shroud, isolates the cylinder from the shock vibration of the anvil. Buffer bumpers absorb the recoil from the Belleville washer type of buffer springs connected to the anvil by buffer bolts, dampening overtravel and holding the hammer together. Pins lock the buffer compression nuts to the buffer bolts and are held captive by the buffer housing caps. The buffer nut bumpers absorb the recoil of the Belleville springs.

RAM-PISTON OVERSTRIKE.— The length of free travel (maximum stroke) of the ram from the bottom of the stroke to the safety catch lip at the top is 109 inches (fig. 12-65). When the ram is recoiled high enough, the ram rings will engage the safety catch lip and prevent it from going out of the top. If the upward force of the ram is too great, the whole hammer will be lifted off the pile, possibly causing the rings to shear. To prevent this danger, watch the projection of the ram above the hammer and reset the throttle when necessary.

Pile-Driving Caps

A pile-driving cap is a block (usually a steel block) that rests on the butt or head of the pile and protects it against damage by receiving and transmitting the blows of the hammer or ram. In the steam, or pneumatic, hammer, the cap is a part of the hammer. The cap with a drop or diesel hammer is a separate casting with the lower part recessed to fit the head or butt of the pile and the upper part recessed to contain a hard cushion block that receives the blows of the hammer. The cap is fitted with a wire rope sling so that the cap, as well as the hammer, may be raised to the top of the leads when positioning a pile in the leads.

On the DE-10 hammer, you place one cushion block in the drive cap and lash the cap to the hammer front and back with two pieces of 1/2-inch wire rope and clips. You must allow 3 to 4 inches of slack in the wire rope. The cap is normally lashed to the hammer after the hammer is placed in the leads.

NOTE: The top of the cushion block should be kept high enough to prevent the hammer shroud from fouling on the rim of the drive cap pocket.

Pile-driving caps are available for driving timber, concrete, sheet, and H-beam piles. Figure 12-66 shows a pile cap designed for driving a H-beam pile.

Placing Hammer in Leads

Placing the pile-driving hammer in the leads is performed two ways: while the leads are horizontal or vertical. Leads are not always used in pile-driving operations. Pile hammers can be used as a flying hammer, using special adapter caps attached to the hammer (fig. 12-67). This is far the most dangerous of all types of pile-driving operations and should be attempted only by experienced personnel.

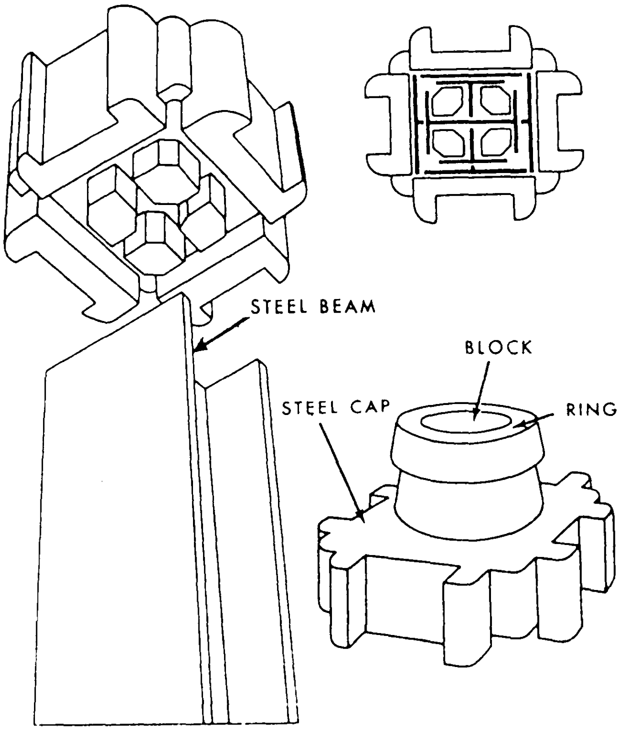


Figure 12-66.-H-beam pile-driving cap.

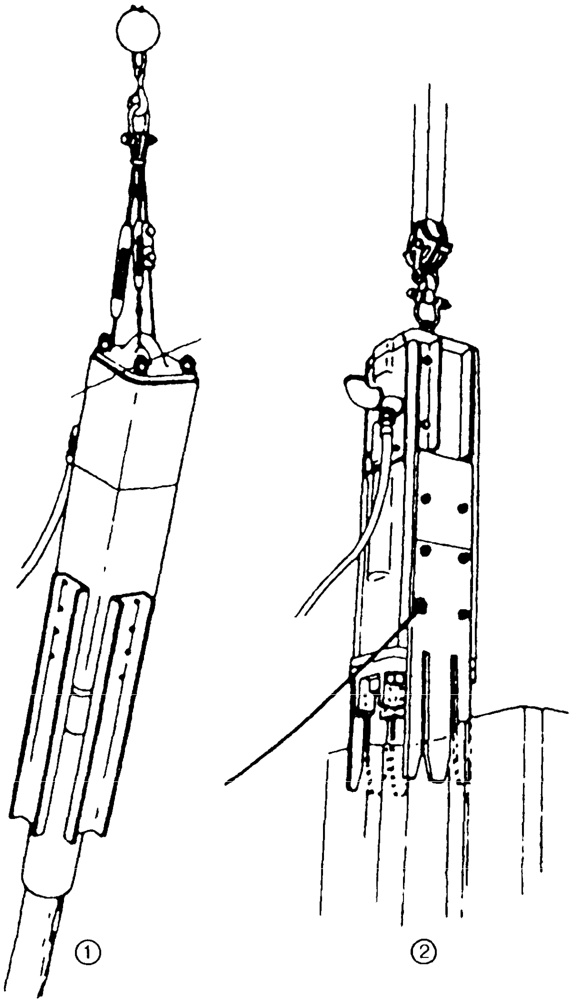


Figure 12-67.—Pile driving using a flying hammer.

The steps required to install the hammer in the leads in the horizontal position are as follows:

1. Block the leads about 18 inches off the ground in several places, keeping them as level as possible.

2. Using a forklift, place the hammer at the base of the leads with the top of the hammer towards the top of the leads.

NOTE: On underhung leads, the fuel pump faces upward. On extended four-way leads, the fuel pump faces downward.

3. Have the forklift approach the hammer from the pile cap end.

4. Adjust the forks so they will just fit the lead guides on the hammer.

5. Pick the hammer up in this manner and guide the top end into the leads as far as it will go without hitting the forks.

6. Block up the hammer that protrudes and reposition the forklift to push the remainder of the hammer into the leads.

NOTE: The crane line may assist in pulling the hammer into the leads.

7. Secure the hammer to the bottom of the leads. This will keep the strain off of the leads, as they are raised to the vertical position by the crane boom.

Installing the hammer in the leads in the vertical position is as follows:

1. Raise the boom and leads from horizontal to vertical and install the catwalk. Continue to raise the boom as high as practical and safety permits.

2. Hoist the hammer to a vertical position and position it under the leads. It takes a combination of lowering the boom and hoisting the hammer to slide the hammer onto the lead guides.

If this does not allow enough clearance to install the hammer vertically, use the following:

1. Use a deep ditch or loading ramp for additional clearance for the hammer.

2, Set the hammer in an excavated hole to clear the bottom of the leads.

3. The hammer can be partially submerged in water to gain additional clearance.

PILE-DRIVING TECHNIQUES AND TERMINOLOGY

Care must be taken during pile driving to avoid damaging the pile, the hammer, or both. The pile driver must be securely anchored to avoid a shift of position. If the hammer shifts while driving, the blow of the hammer will be out of line with the axis of the pile and both the pile and hammer may be damaged.

Carefully watch the piles for any indication of a split or brake below the ground. If driving suddenly becomes easier or if the pile suddenly changes direction, a break or split has probably occurred. When this happens, the pile must be pulled.

Springing and Bouncing

"Springing" means that the pile vibrates too much laterally from the blow of the hammer. Springing may occur when a pile is crooked, when the butt has not been squared off properly, or when the pile is not in line with the fall of the hammer. In all pile-driving operations, ensure the fall of the hammer is in line with the pile axis; otherwise, the head of the pile and the hammer may be damaged and much of the energy of the hammer blow is lost.

Excessive bouncing may come from a hammer which is too light. However, it usually occurs when the butt of the pile has been crushed or broomed, when the pile has met an obstruction, or when the pile has penetrated to a solid footing. When a double-acting hammer is being used, bouncing may result from too much steam or air pressure. With a diesel hammer, if the hammer lifts on the upstroke of the ram piston, the throttle setting is probably too high. Back off on the throttle control just enough to avoid this lifting. If the butt of the timber pile has been crushed or broomed more than an inch or so, it should be cut back to sound wood before driving operations continue.

Driving Bearing Piles in Groups

Bearing piles are frequently driven in groups, as in a pile group which will support a column footing for a building or in closely spaced rows, as beneath a wall. When piles must be driven in closely spaced groups, these principles are observed:

1. When a pile is driven into sand or gravel deposits, the soil must be compacted or displaced an amount equal to the volume of the pile. If the deposit is quite loose, the vibration of pile driving frequently results in considerable compaction of the soil. The

surface of the ground between and around the piles then may subside or shrink. This action may result in damage to the foundation of nearby structures. If piles are driven into dense sand and gravel deposits, the ground may heave.

2. Clay soils are hard to compress in pile driving; hence, a volume of soil equal to that of the pile will usually be displaced (fig. 12-68). The ground will heave between and around the piles. Driving a pile alongside those previously driven will frequently cause those already in place to heave upward. If the piles are driven through a clay stratum to firm bearing beneath, the heave may destroy the contact between the tip of the pile and the firm stratum. Such cases maybe detected by taking a level reading on the top of the piles previously placed. Piles which are raised appreciably should be redriven to a firm bearing. Soil displaced by the pile may cause enough lateral force to move previously driven piles out of line.

3. The sequence of driving piles in groups should be as follows:

- Driving should progress from an area of high resistance to one of low resistance, toward a stream, or downslope to reduce the shoving of previous driven piles that are out of place when succeeding piles arc driven.
- Outer rows in the group should be driven first if the piles derive their main support from friction. Inner rows are driven first if the piles are supported from a point bearing.

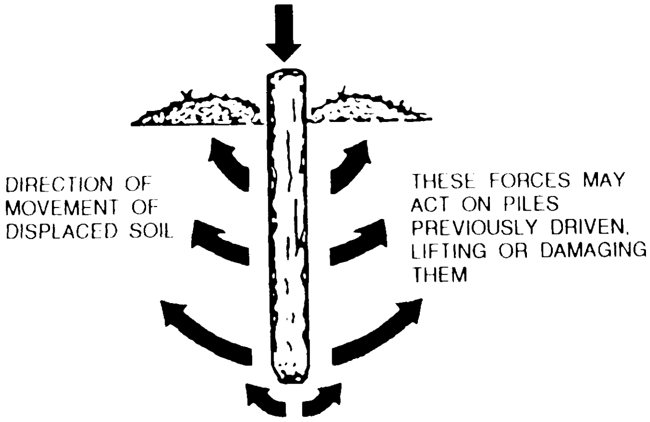

DIRECTION OF MOVEMENT OF DISPLACED SOIL
THESE FORCES MAY ACT ON PILES PREVIOUSLY DRIVEN, LIFTING OR DAMAGING THEM

Figure 12-68.-Displacement of clay soil caused by driving solid piles.

Obstruction and Refusal

The condition reached when a pile being driven by a hammer has a 1-inch penetration per blow or zero penetration per blow (as when the point of the pile reaches an impenetrable bottom such as rock) or when the effective energy of the hammer is no longer sufficient to cause penetration (hammer is to light or velocity at impact too little), under which circumstances the pile may cease to penetrate before it has reached the desired depth is known as refusal. Further driving after refusal is likely to break or split the pile, as shown in figure 12-69.

When a pile has been driven to a depth where deeper penetration is prevented by friction, the pile has been driven to refusal. A pile supported by skin friction alone is called a **friction pile.** A pile supported by bedrock or

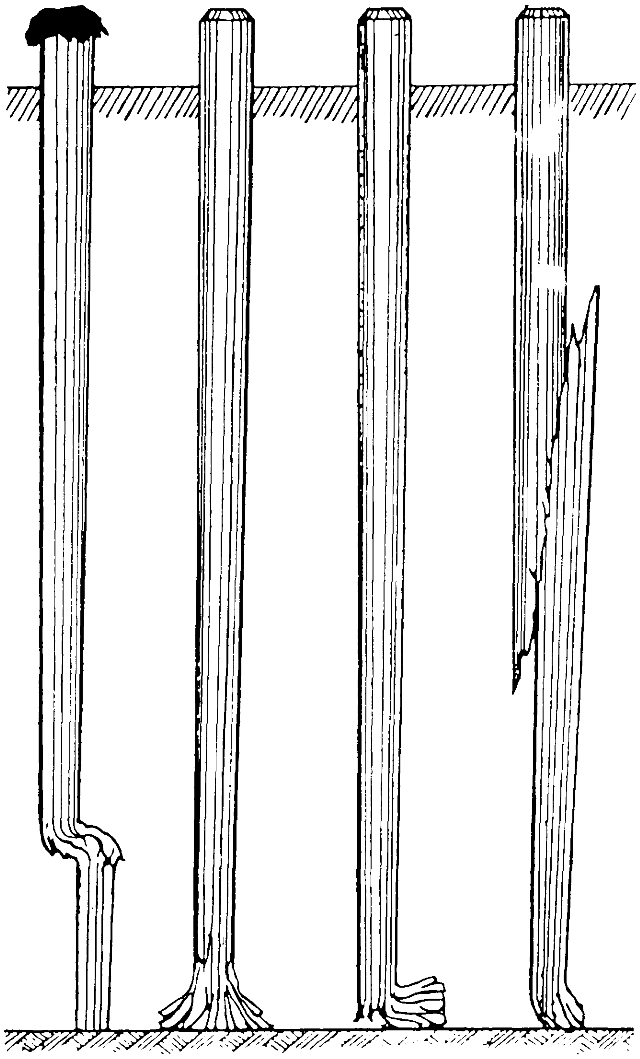


Figure 12-69.—Pile damage caused by overdriving timber piles.

an extra dense layer of soil at the tip is called an **end-bearing pile.** A pile supported partly by skin friction and partly by a substratum of extra dense soil at the tip is called a **combination end-bearing and friction pile.**

It is not always necessary to drive a friction pile to refusal; such a pile needs to be driven only to the depth where friction develops the required load-bearing capacity.

Straightening and Aligning Piles

Piles should be straightened when any misalignment is noticed during pile driving. The accuracy of alignment that should be sought for the finished job depends on various factors, but if a pile is more than a few inches out of its plumb line, an effort should be made to true it up. The greater the penetration along the wrong alignment, the harder it is to get the pile back to plumb.

One method of alignment is to use pull from a block and tackle (fig. 12-70) with the impact of the hammer jarring the pile back into line. The straightening of steel bearing piles must include twisting of the individual piles to bring the webs of the piles parallel to the center line of the bent.

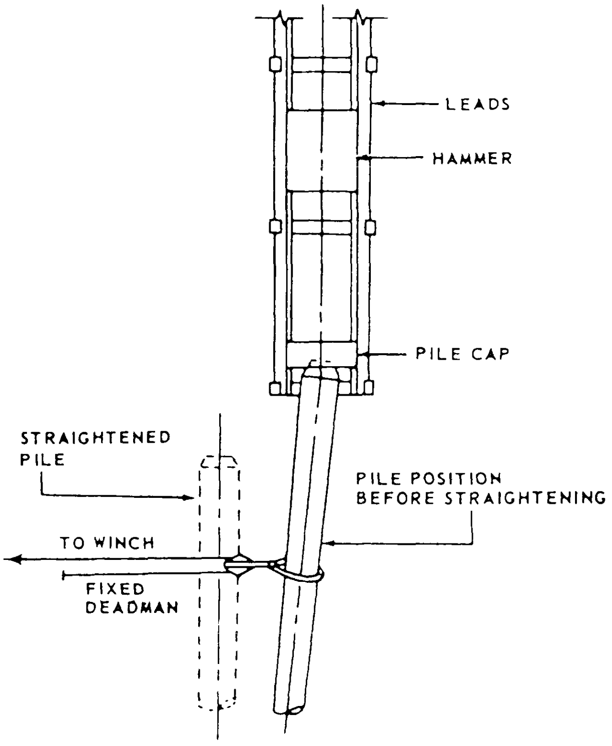

LEADS
HAMMER
PILE CAP
STRAIGHTENED PILE
PILE POSITION BEFORE STRAIGHTENING
TO WINCH
FIXED DEADMAN

Figure 12-70.-Realigning pile using block and tackle.

Another method of alignment is to use a jet (fig. 12-71), either alone or jointly, with the block-and-tackle method

When all piles in a bent have been driven, they may be pulled into proper spacing and alignment with block and tackle and an aligning frame, as shown in figures 12-72 and 12-73.

Pulling Files

A pile that has met an obstruction, that has been driven in the wrong place, that has split or broken in

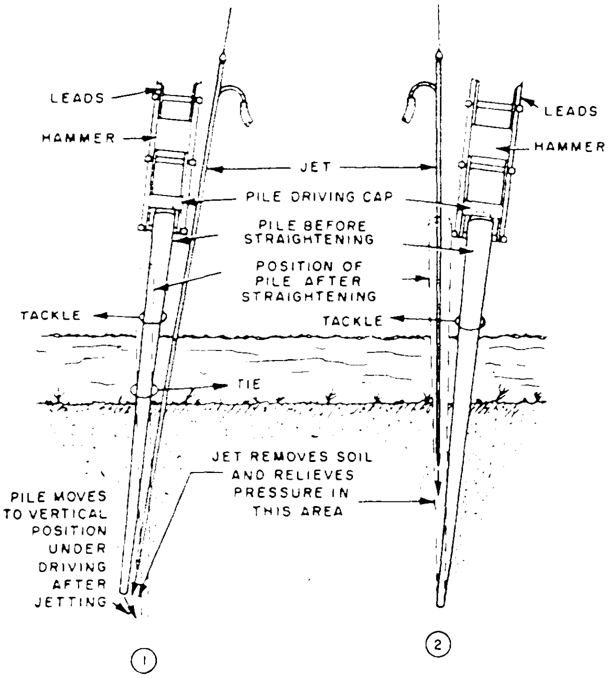

LEADS
HAMMER
JET
PILE DRIVING CAP
PILE BEFORE STRAIGHTENING
POSITION OF PILE AFTER STRAIGHTENING
TACKLE
TACKLE
TIE
JET REMOVES SOIL AND RELIEVES PRESSURE IN THIS AREA
PILE MOVES TO VERTICAL POSITION UNDER DRIVING AFTER JETTING
LEADS
HAMMER
①
②

Figure 12-71.—Realigning pile by jetting.

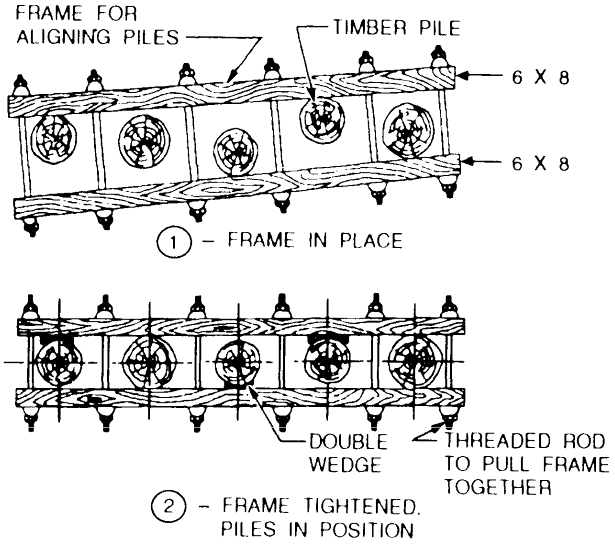

FRAME FOR ALIGNING PILES
TIMBER PILE
6 X 8
6 X 8
① - FRAME IN PLACE
DOUBLE WEDGE
THREADED ROD TO PULL FRAME TOGETHER
② - FRAME TIGHTENED. PILES IN POSITION

Figure 12-72.—Aligning frame used for timber pile bent.

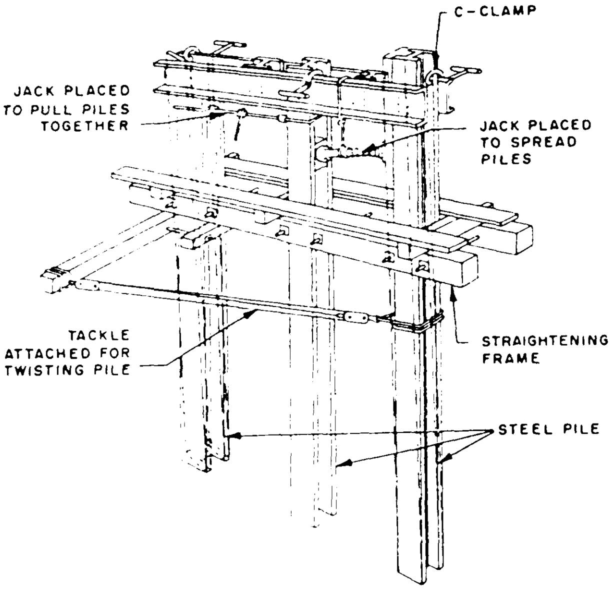

C-CLAMP
JACK PLACED TO PULL PILES TOGETHER
JACK PLACED TO SPREAD PILES
TACKLE ATTACHED FOR TWISTING PILE
STRAIGHTENING FRAME
STEEL PILE

Figure 12-73.—Aligning and capping steel pile bents.

driving, or that is to be salvaged (steel sheet piles are frequently salvaged for reuse) is usually **extracted** (pulled). Pulling should be done as soon as possible after driving; the longer the pile stays in the soil, the more compact the soil becomes, and the greater the resistance to pulling will be. Methods of pulling piles are as follows:

1. In a **direct lift** method, a crane palls the pile. The crane hoist line is rigged to the pile through the use of wire rope rigging, and an increase in pull is gradually applied to the pile. Lateral blows from a **skull cracker** (heavy steel ball swung on a crane line to demolish walls) or a few light blows on the butt or head with the pile-driving hammer are given to break the skin friction, and the crane pull is then increased. If the pile still refuses to extract, it may be loosened by jetting, air extractors, or beam pullers.

2. The 5,000-pound pneumatic, or steam, hammer may be used in an inverted position to pull piles. The hammer is turned over and the wire rope rigging is attached to it and the pile is extracted. A pneumatic extractor may also be used. The crane line, holding the hammer or extractor, is hoisted taut; and the upward blows of the hammer ram on the sling, plus the pull of the crane hoist, are usually enough to pull the pile.

3. Tidal lift is often used to pull piles driven in tidewater. Rigging, wrapped around the piles, is attached to barges or pontoons at low tide; the rising tide pulls the piles as it lifts the barges or pontoons.

Types of Piles

The principal use of piles is for the support of bridges, buildings, wharves, docks and other structures, and in temporary construction. A pile transfers the load into an underlying bearing stratum by either of the following:

1. Friction along the embedded length of the pile

2. Point bearing plus any bearing from the taper of the pile

A pile maybe classified roughly as **friction** or **end bearing,** according to the manner in which they develop support. The load must be carried ultimately by the soil layers around and below the points of the piles, and accurate knowledge of the compressibility of these soil layers is of utmost importance.

Some of the common terms used with piles are as follows:

1. Piles. A pile is a load-bearing member made of timber, steel, concrete, or a combination of these materials, usually forced into the ground to transfer the load to underlying soil or rock layers when the surface soils at a proposed site are too weak or compressible to provide enough support.

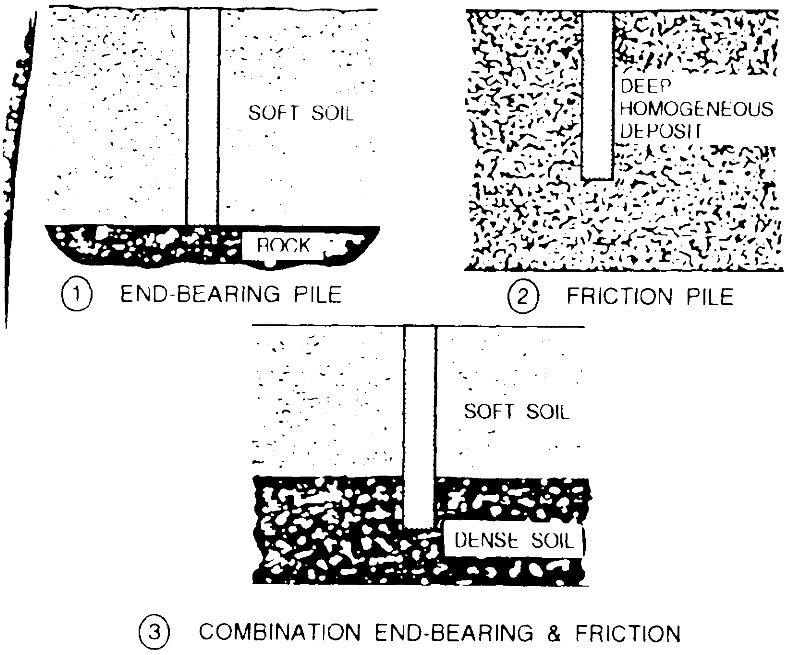
2. Pile foundation. A pile foundation is a group of piles that supports a superstructure or a number of piles distributed over a large area to support a mat foundation.

3. Bearing piles. Piles that are driven vertically and used for the direct support of vertical loads are called bearing piles. Bearing piles transfer the load through a soft soil to an underlying firm stratum. They also distribute the load through relatively soft soils that are not capable of supporting concentrated loads.

4. End-bearing piles. Typical end-bearing piles are driven through very soft soil, such as a loose silt-bearing stratum underlain by compressible strata. Remember this factor when determining the load the piles can support safely.

5. Friction piles. When a pile is driven into soil of fairly uniform consistency and the tip is not seated in a hard layer, the load-carrying capacity of the pile is developed by skin friction. The load is transferred to the adjoining soil by friction between the pile and the surrounding soil. The load is transferred downward and laterally to the soil.

6. Combination end-bearing and friction piles. Many piles carry loads by a combination of friction and end bearing. For example, a pile may pass through a



① END-BEARING PILE ② FRICTION PILE

③ COMBINATION END-BEARING & FRICTION

Figure 12-74.—Types of bearing piles.

fairly soft soil that provides frictional resistance and then into a form layer which develops a load-carrying capacity by both end bearing and friction over a rather short length of embedment (fig. 12-74).

7. Batter piles. Piles driven at an angle with the vertical are called batter piles. They resist lateral or incline loads when such loads are huge or when the foundation material immediately beneath the structure fails to resist the lateral movement of vertical piles. They also may be used if piles are driven into a compressible soil to spread vertical loads over a large area thereby reducing final settlement. They may be used alone (battered in opposite directions) or with vertical piles.

8. Anchor piles. An anchor pile may be used to anchor bulkheads, retaining walls, and guy wires. They resist tension or uplift loads (fig. 12-75).

9. Dolphin piles. As shown in figure 12-75, dolphin piles are a group of piles driven close together in water and tied together so that the group will withstand lateral forces, such as boats and other floating objects.

10. Fender piles. As shown in figure 12-75, fender piles are driven in front of a structure to protect it from damage.

11. Foot of pile. As shown in figure 12-75, the foot of a pile is the lower end of a driven pile, which is the smaller end.

12. Guide piles. Piles used as a guide for driving other piles or serving as a support as a wale for sheetpiling.

13. Pile bent. Two or more piles driven in a row transverse to the long dimension of the structure and are fastened together by capping and (sometimes) bracing.

14. Pile foundation. A group of piles used to support a column or pier, a row of piles under a wall, or a number of piles distributed over a large area to support a mat foundation.

15. Pile group. A number of bearing piles driven close together to form a pile foundation.

16. Test piles. A pile driven to determine driving conditions and probable required lengths; one on which a loading test may also be made to find its load settlement properties and the carrying capacity of the soil and as a guide in designing pile foundations.

17. Timber piles. Common timber piles are usually straight tree trunks cut off aboveground swell, trimmed of branches, and the bark removed. A good timber pile has the following characteristics:

Ž It is free of sharp bends, large or loose knots, splits or decay.

Ž It has a straight line between centers of the butt and tip and lies within the body of the pile.

Ž It has a uniform taper from butt to tip.

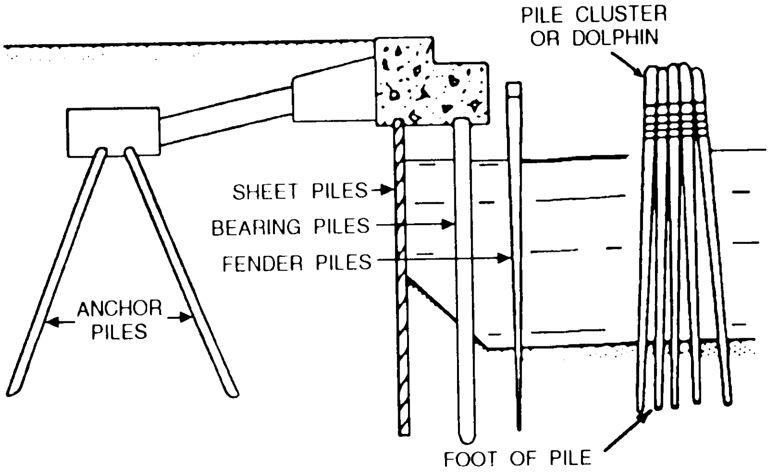

PILE CLUSTER OR DOLPHIN
SHEET PILES
BEARING PILES
FENDER PILES
ANCHOR PILES
FOOT OF PILE

Figure 12-75.—Typical uses of piles driven in a waterfront structure.

18. Treated timber pile. A timber pile impregnated with a preservative material that retards or prevents deterioration due to organisms.

WARNING

> When you are working with treated piles, protective clothing, such as long sleeves, gloves, and safety goggles, must be worn. The preservative used in treated piles can irritate the eyes and skin.

19. Concrete piles. Two types of concrete piles are precast and cast-in-place. Factors contributing to their use are the availability of the materials from which concrete is made.

- Precast concrete piles are steel reinforced sections that are square or octagonal in shape except near the tip. They vary in length up to 50 or 60 feet. Because of their great weight, greater lengths are generally not feasible. They require time for setting and curing and storage space. Precast concrete piles are frequently driven with the aid of water jetting (fig. 12-76). Water is forced through and out the pile tip through jetting pipes constructed into the piles while the pile is driven.

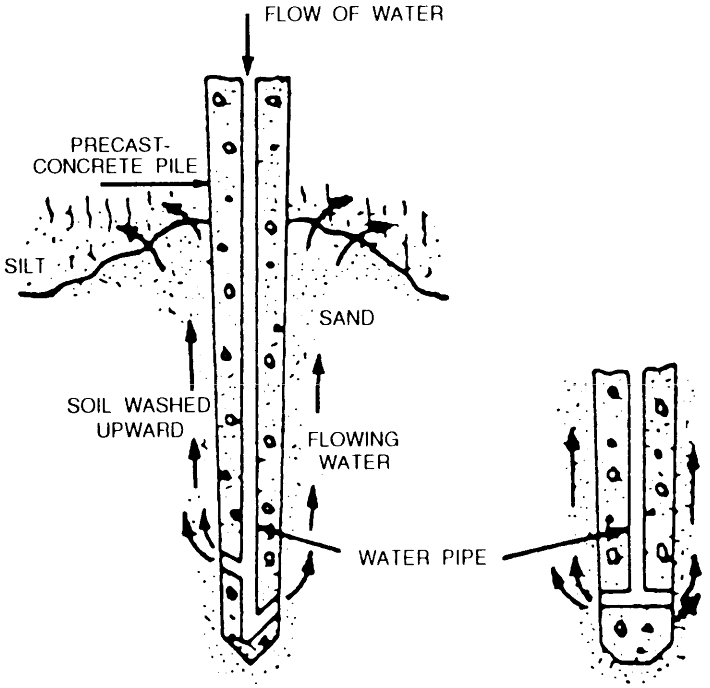

FLOW OF WATER
PRECAST-CONCRETE PILE
SILT
SAND
SOIL WASHED UPWARD
FLOWING WATER
WATER PIPE

Figure 12-76.—Water jetting precast concrete pile.

- Cast-in-place concrete piles may be used when conditions are favorable. They are made by pouring concrete into a tapered hole or cylindrical form previously driven into the ground or into a hole in the ground from which a driven mandrel has been withdrawn. The left-in-place form may be a steel shell heavy enough to be driven without a mandrel, or it may be a steel form designed for driving with a mandrel that is removed on completion of driving (fig. 12-77).

20. Composite piles. Composite piles are formed of one material in the lower section and another material in the upper section (fig. 12-78). A composite pile that is constructed of wood and concrete is used to support loads of 20 to 30 tons. A composite pile that is constructed of steel and concrete is used to support loads up to 50 tons. As shown in figure 12-78, the first section of wood or steel is driven first, then a mandrel and steel casing are driven on top of the first section. The mandrel is removed and the casing is filled with concrete.

21. Sheet piles. Sheet piles are special shapes of interlocking piles that are made of steel, wood, or formed concrete which are used to forma continuous wall to resist horizontal pressures, resulting from earth or water loads.

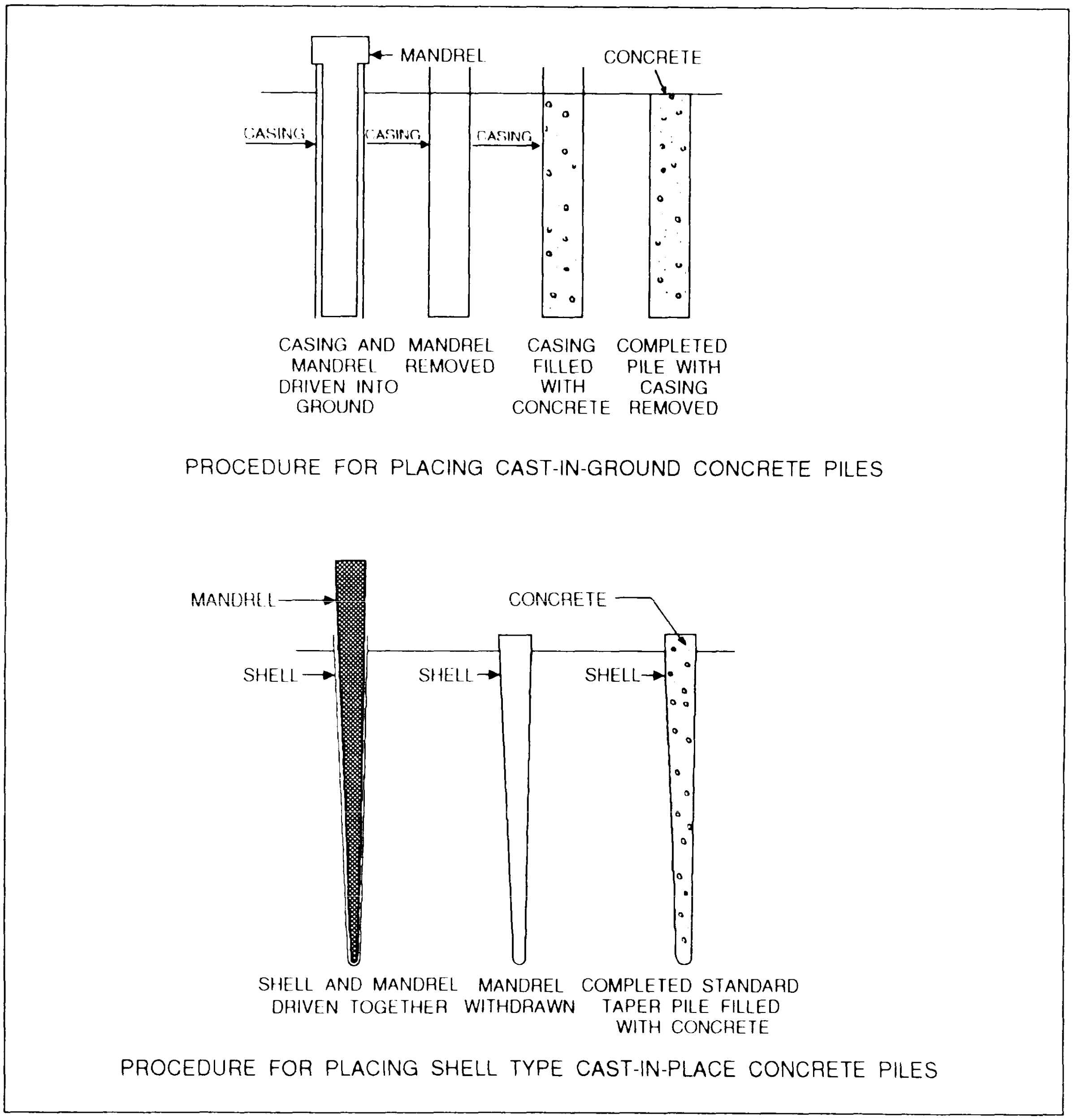

MANDREL
CONCRETE
CASING
CASING
CASING
CASING AND MANDREL DRIVEN INTO GROUND
MANDREL REMOVED
CASING FILLED WITH CONCRETE
COMPLETED PILE WITH CASING REMOVED
PROCEDURE FOR PLACING CAST-IN-GROUND CONCRETE PILES
MANDREL
CONCRETE
SHELL
SHELL
SHELL
SHELL AND MANDREL DRIVEN TOGETHER
MANDREL WITHDRAWN
COMPLETED STANDARD TAPER PILE FILLED WITH CONCRETE
PROCEDURE FOR PLACING SHELL TYPE CAST-IN-PLACE CONCRETE PILES

Figure 12-77.—Cast-in-place concrete piles.

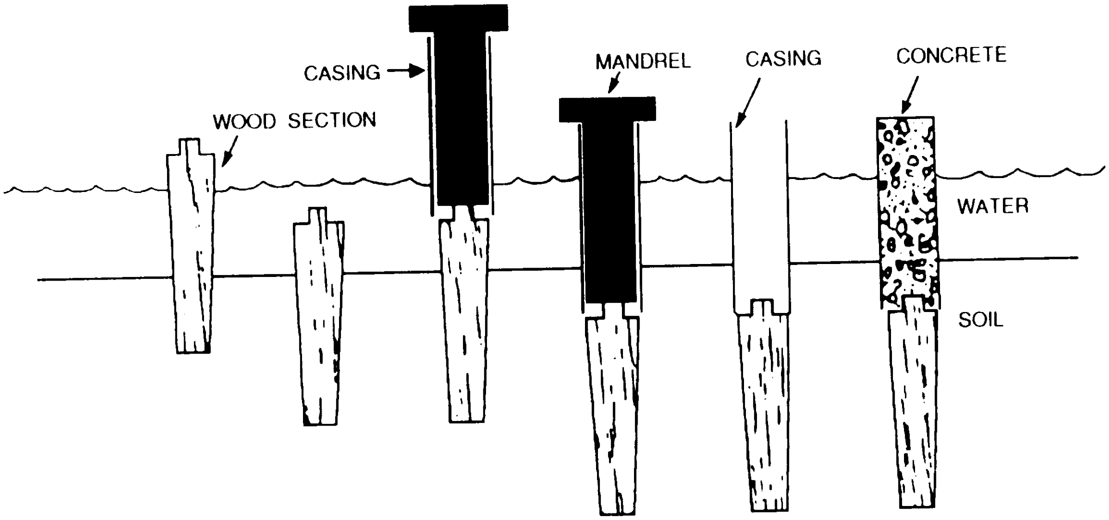

CASING
WOOD SECTION
MANDREL
CASING
CONCRETE
WATER
SOIL

Figure 12-78.-Composite piles.

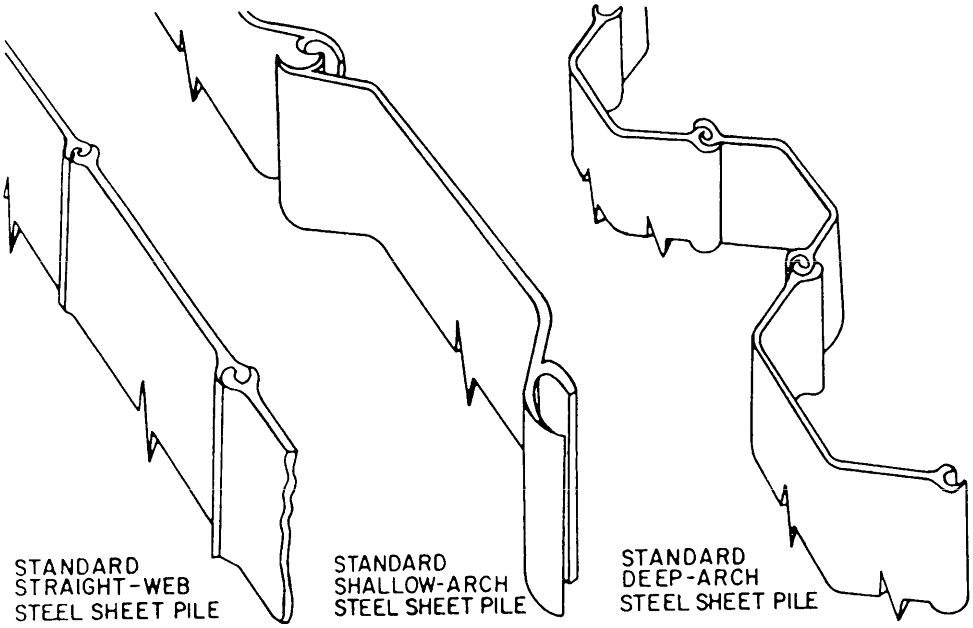

STANDARD STRAIGHT-WEB STEEL SHEET PILE
STANDARD SHALLOW-ARCH STEEL SHEET PILE
STANDARD DEEP-ARCH STEEL SHEET PILE

Figure 12-79.—Types of steel sheetpiling.

The most common types of sheet piles are straight-web, shallow-arch, and deep-arch (fig. 12-79).

The straight-web section is designed for maximum flexibility and tensile strength, particularly adapted to cellular cofferdam and retaining wall construction. The shallow-arch and deep-arch sections are multipurpose sections having some resistance to bending.

CHAPTER 13

RIGGING

Rigging is a technique of handling materials using wire rope, fiber rope, chains, slings, spreader bars, and so forth. Rigging is a vital link in the weight-handling process.

In the Naval Construction Force (NCF), an in-depth management program for maintenance and use of all rigging gear is required to ensure the entire weight-handling operations are performed safely and professionally. These guidelines are outlined in the COMSECOND/COMTHIRDNCBINST 11200.11, *Use of Wire Rope Slings and Rigging Hardware in the Naval Construction Force.*

This chapter covers the characteristics, maintenance, usage, and storage of rigging gear used in weight-handling operations.

WIRE ROPE

Many of the movable components on cranes and attachments are moved by wire rope. Wire rope is a complex machine, composed of a number of precise, moving parts. The moving parts of wire rope are designed and manufactured to bear a definite relationship to one another to have the necessary flexibility during operation.

Wire rope may be manufactured by either of two methods. If the strands, or wires, are shaped to conform to the curvature of the finished rope before laying up, the rope is termed **preformed wire rope.** If they are not shaped before fabrication, the wire rope is termed **non-preformed wire rope.**

The most common type of manufactured wire rope is preformed. When cut, the wire rope tends not to unlay and is more flexible than non-preformed wire rope. With non-preformed wire rope, twisting produces a stress in the wires; therefore, when it is cut or broken, the stress causes the strands to unlay.

NOTE: When the wire is cut or broken, the almost instantaneous unlaying of the wires and strands of non-preformed wire rope can cause serious injury to someone that is careless or not familiar with this characteristic of the rope.

PARTS OF WIRE ROPE

Wire rope is composed of three parts: **wires, strands,** and **core** (fig. 13- 1). A predetermined number of wires of the same or different size are fabricated in a uniform arrangement of definite lay to form a strand. The required number of strands are then laid together symmetrically around the core to form the wire rope.

Wire

The basic component of the wire rope is the wire. The wire may be made of steel, iron, or other metal in various sizes. The number of wires to a strand varies, depending on the purpose for which the wire rope is intended. Wire rope is designated by the number of strands per rope and the number of wires per strand. Thus an 1/2-inch 6 x 19 rope has six strands with 19 wires per strand. It has the same outside diameter as a 1/2-inch 6 x 37 rope that has six strands with 37 wires (of smaller size) per strand.

Strand

The design arrangement of a strand is called the construction. The wires in the strand maybe all the same size or a mixture of sizes. The most common strand

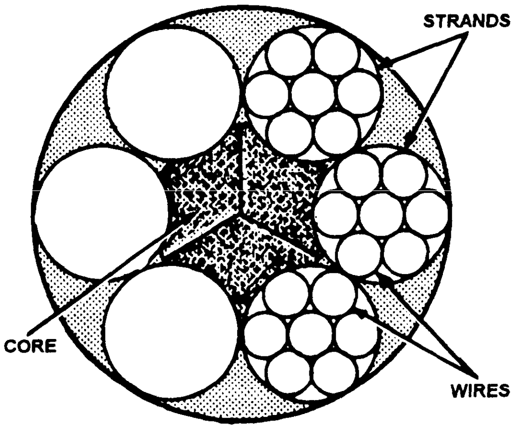


Figure 13-1.—Parts of wire rope.

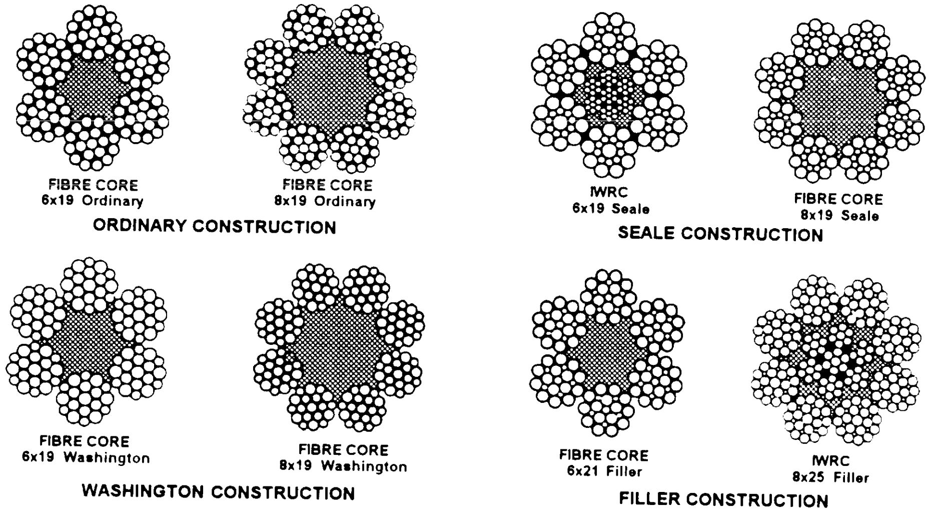

FIBRE CORE
6x19 Ordinary
FIBRE CORE
8x19 Ordinary
ORDINARY CONSTRUCTION
IWRC
6x19 Seale
FIBRE CORE
8x19 Seale
SEALE CONSTRUCTION
FIBRE CORE
6x19 Washington
FIBRE CORE
8x19 Washington
WASHINGTON CONSTRUCTION
FIBRE CORE
6x21 Filler
IWRC
8x25 Filler
FILLER CONSTRUCTION

Figure 13-2.—Common strand construction.

constructions are Ordinary, Seale, Warrington, and Filler (fig. 13-2).

- **Ordinary** construction wires are all the same size.

- **Seale** is where larger diameter wires are used on the outside of the strand to resist abrasion and smaller wires are inside to provide flexibility.

- **Warrington** is where alternate wires are large and small to combine great flexibility with resistance to abrasion.

- **Filler** is where very small wires fill in the valleys between the outer and inner rows of wires to provide good abrasion and fatigue resistance.

Core

The wire rope core supports the strands laid around it. The three types of wire rope cores are fiber, wire strand, and independent wire rope (fig. 13-3).

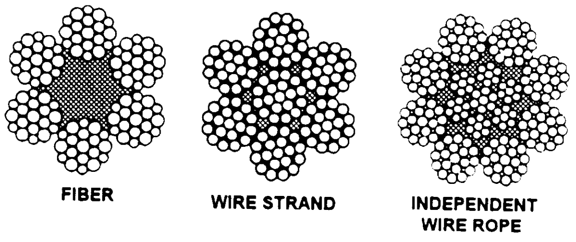

FIBER
WIRE STRAND
INDEPENDENT
WIRE ROPE

Figure 13-3.—Core construction.

- A **fiber core** may be a hard fiber, such as manila, hemp, plastic, paper, or sisal. The fiber core offers the advantage of increased flexibility. It also serves as a cushion to reduce the effects of sudden strain and acts as an oil reservoir to lubricate the wire and strands (to reduce friction). Wire rope with a fiber core is used when flexibility of the rope is important.

- A **wire strand core** resists more heat than a fiber core and also adds about 15 percent to the strength of the rope; however, the wire strand core makes the wire rope less flexible than a fiber core.

- An **independent wire rope core** is a separate wire rope over which the main strands of the rope are laid. This core strengthens the rope, provides support against crushing, and supplies maximum resistance to heat.

GRADES OF WIRE ROPE

The three primary grades of wire rope are mild plow steel, plow steel, and improved plow steel.

Mild Plow Steel Wire Rope

Mild plow steel wire rope is tough and pliable. It can stand repeated strain and stress and has a tensile strength (resistance to lengthwise stress) of from 200,000 to 220,000 pounds per square inch (psi). These characteristics make it desirable for cable tool drilling and other purposes where abrasion is encountered.

Plow Steel Wire Rope

Plow steel wire rope is unusually tough and strong. This steel has a tensile strength of 220,000 to 240,000 psi. Plow steel wire rope is suitable for hauling, hoisting, and logging.

Improved Plow Steel Wire Rope

Improved plow steel wire rope is one of the best grades of rope available and is the most common rope used in the NCF. This type of rope is stronger, tougher, and more resistant to wear than either mild plow steel or plow steel. Each square inch of improved plow steel can stand a strain of 240,000 to 260,000 pounds. This makes it especially useful for heavy-duty service, such as on cranes with excavating and weight-handling attachments.

LAYS OF WIRE ROPE

The term **lay** refers to the direction of the twist of the wires in a strand and to the direction that the strands are laid in the rope. In some instances, both the wires in the strand and the strands in the rope are laid in the same direction; and in other instances, the wires are laid in one direction and the strands are laid in the opposite direction, depending on the intended use of the rope. Most manufacturers specify the types and lays of wire rope to be used on their piece of equipment. Be sure and consult the operator's manual for proper application.

Five different lays of wire rope are shown in figure 13-4.

The five types of lays used in wire rope are as follows:

- **Right Regular Lay:** In right regular lay rope, the wires in the strands are laid to the left, while the strands are laid to the right to form the wire rope.
- **Left Regular Lay:** In left regular lay rope, the wires in the strands are laid to the right, while the strands are laid to the left to form the wire rope. In this lay, each step of fabrication is exactly opposite from the right regular lay.
- **Right Lang Lay:** In right lang lay rope, the wires in the strands and the strands in the rope are laid in the same direction; in this instance, the lay is to the right.
- **Left Lang Lay:** In left lang lay rope, the wires in the strands and the strands in the rope are also laid in the same direction; in this instance, the lay is to the left (rather than to the right as in the right lang lay).

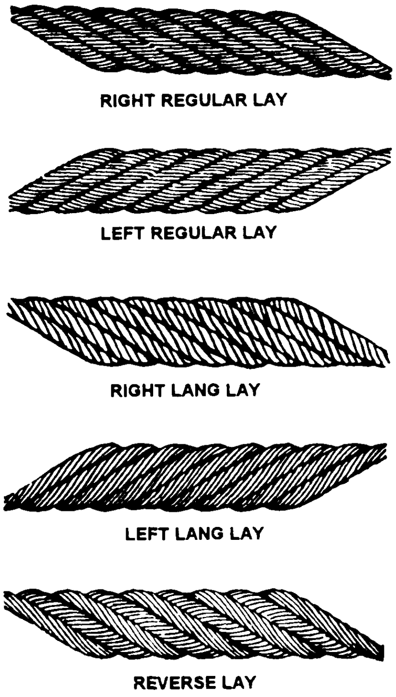


Figure 13-4.—Lays of wire rope.

- **Reverse Lay:** In reverse lay rope, the wires in one strand are laid to the right, the wires in the nearby strand are laid to the left, the wires in the next strand are to the right, and so forth, with alternate directions from one strand to the other. Then all strands are laid to the right.

LAY LENGTH OF WIRE ROPE

The length of a rope lay is the distance measured parallel to the center line of a wire rope in which a strand makes one complete spiral or turn around the rope. The length of a strand lay is the distance measured parallel to the center line of the strand in which one wire makes one complete spiral or turnaround the strand. Lay length measurement is shown in figure 13-5.

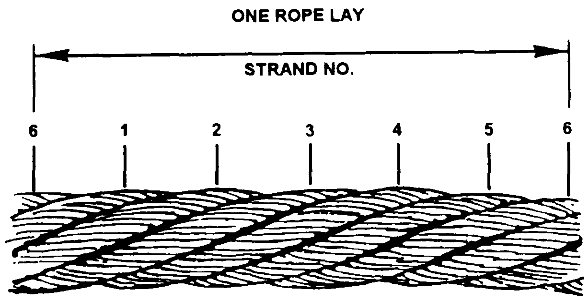


Figure 13-5.—Lay length of wire rope.

CHARACTERISTICS OF WIRE ROPE

The main types of wire rope used by the NCF consist of 6, 7, 12, 19, 24, or 37 wires in each strand. Usually, the wire rope has six strands laid around the core.

The two most common types of wire rope, 6 X 19 and 6 x 37, are shown in figure 13-6. The 6 x 19 type (having six strands with 19 wires in each strand) is the stiffest and strongest construction of the types of wire rope suitable for general hoisting operations. The 6 x 37 wire rope (six strands with 37 wires in each strand) is very flexible, making it suitable for cranes and similar equipment where sheaves are smaller than usual. The wires in the 6 x 37 are smaller than the wires in the 6 x 19 wire rope and, consequently, will not stand as much abrasive wear.

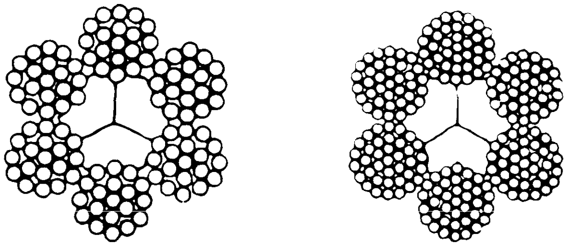
Several factors must be considered whenever a wire rope is selected for use in a particular kind of operation. The manufacture of a wire rope which can withstand equally well all kinds of wear and stress, it may be subjected to, is not possible, Because of this, selecting a rope is often a matter of compromise, sacrificing one quality to have some other more urgently needed characteristic.

Tensile Strength

Tensile strength is the strength necessary to withstand a certain maximum load applied to the rope. It includes a reserve of strength measured in a so-called factor of safety.

Crushing Strength

Crushing strength is the strength necessary to resist the compressive and squeezing forces that distort the cross section of a wire rope, as it runs over sheaves, rollers, and hoist drums when under a heavy load. Regular lay rope distorts less in these situations than lang lay.



A 6 STRANDS OF 19 WIRES (6 x 19)

B 6 STRANDS OF 37 WIRES (6 x 37)

Figure 13-6.-A. 6 x 19 wire rope; B. 6 x 37 wire rope.

Fatigue Resistance

Fatigue resistance is the ability to withstand the constant bending and flexing of wire rope that runs continuously on sheaves and hoist drums. Fatigue resistance is important when the wire rope must run at high speeds. Such constant and rapid bending of the rope can break individual wires in the strands. Lang lay ropes are best for service requiring high fatigue resistance. Ropes with smaller wires around the outside of their strands also have greater fatigue resistance, since these strands are more flexible.

Abrasion Resistance

Abrasion resistance is the ability to withstand the gradual wearing away of the outer metal, as the rope runs across sheaves and hoist drums. The rate of abrasion depends mainly on the load carried by the rope and its running speed. Generally, abrasion resistance in a rope depends on the type of metal of which the rope is made and the size of the individual outer wires. Wire rope made of the harder steels, such as improved plow steel, have considerable resistance to abrasion. Ropes that have larger wires forming the outside of their strands are more resistant to wear than ropes having smaller wires which wear away more quickly.

Corrosion Resistance

Corrosion resistance is the ability to withstand the dissolution of the wire metal that results from chemical attack by moisture in the atmosphere or elsewhere in the working environment. Ropes that are put to static work, such as guy wires, may be protected from corrosive elements by paint or other special dressings. Wire rope may also be galvanized for corrosion protection. Most wire ropes used in crane operations must rely on their lubricating dressing to double as a corrosion preventive.

MEASURING WIRE ROPE

Wire rope is designated by its diameter in inches, as shown in figure 13-7. The correct method of measuring the wire rope is to measure from the top of one strand to the top of the strand directly opposite it. The wrong way is to measure across two strands side by side.

To ensure an accurate measurement of the diameter of a wire rope, always measure the rope at three places,

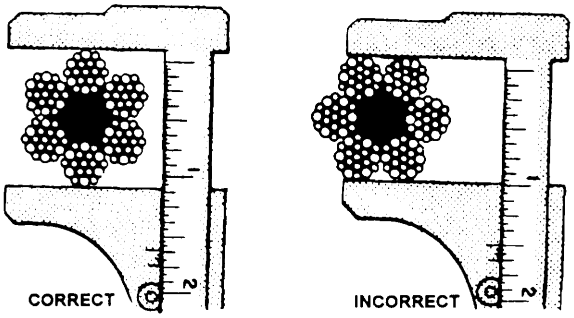


Figure 13-7.-Correct and incorrect methods of measuring wire rope.

at least 5 feet apart. Use the average of the three measurements as the diameter of the rope.

NOTE: A crescent wrench can be used as an expedient means to measure wire rope.

WIRE ROPE SAFE WORKING LOAD

The term *safe working load* (SWL) of wire rope means the load that can be applied and still obtain the most efficient service and also prolong the life of the rope.

The formula for computing the SWL of a wire rope is the diameter of the rope squared, multiplied by 8 (D x D x 8 = SWL in tons).

Example: The wire rope is 1/2 inch in diameter. Compute the SWL for the rope.

The first step is to convert the 1/2 into decimal number by dividing the bottom number of the fraction into the top number of the fraction: (1 divided by 2 = .5). Next, compute the SWL formula: (.5 x .5 x 8 = 2 tons). The SWL of the 1/2-inch wire rope is 2 tons.

NOTE: Do NOT downgrade the SWL of wire rope due to being old, worn, or in poor condition. Wire rope in these conditions should be cut up and discarded.

WIRE ROPE FAILURE

Some of the common causes of wire rope failure are the following:

- Using incorrect size, construction, or grade
- Dragging over obstacles
- Lubricating improperly
- Operating over sheaves and drums of inadequate size
- Overriding or crosr winding on drums
- Operating over sheaves and drums with improperly fitted grooves or broken flanges
- Jumping off sheaves
- Exposing to acid or corrosive liquids or gases
- Using an improperly attached fitting
- Allowing grit to penetrate between the strands, promoting internal wear
- Subjecting to severe or continuing overload
- Using an excessive fleet angle

HANDLING AND CARE OF WIRE ROPE

To render safe, dependable service over a maximum period of time, you should take good care and upkeep that is necessary to keep the wire rope in good condition. Various ways of caring for and handling wire rope are listed below.

Coiling and Uncoiling

Once a new reel has been opened, it maybe coiled or faked down, like line, The proper direction of coiling is **counterclockwise** for **left lay** wire rope and **clockwise** for **right lay** wire rope. Because of the general toughness and resilience of wire, it tends now and then to resist being coiled down. When this occurs, it is useless to fight the wire by forcing down the turn because it will only spring up again. But if it is thrown in a back turn, as shown in figure 13-8, it will lie down properly. A wire rope, when faked down, will run right

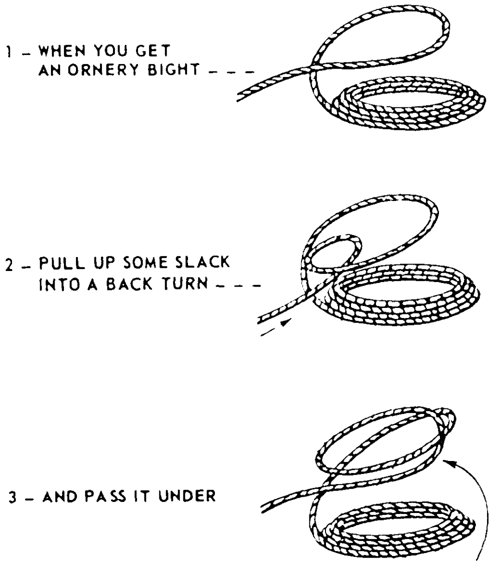

1 – WHEN YOU GET AN ORNERY BIGHT – – –
2 – PULL UP SOME SLACK INTO A BACK TURN – – –
3 – AND PASS IT UNDER

Figure 13-8.—Throwing a back turn.

off, like line; but when wound in a coil, it must always be unwound.

Wire rope tends to kink during uncoiling or unreeling, especially if it has been in service long. A kink can cause a weak spot in the rope that wears out quicker than the rest of the rope.

A good method for unreeling wire rope is to run a pipe, or rod, through the center and mount the reel on drum jacks or other supports so the reel is off the ground, as shown in figure 13-9. In this way, the reel will turn as the rope is unwound, and the rotation of the reel helps keep the rope straight. During unreeling, pull the rope straight forward, and avoid hurrying the operation. As a safeguard against kinking, NEVER unreel wire rope from a reel that is stationary.

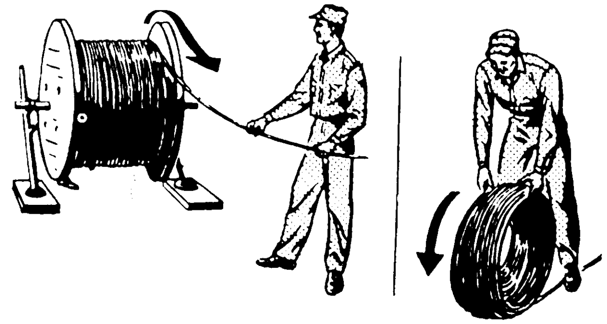


Figure 13-9.-Unreeling wire rope (left); uncoiling wire rope (right).

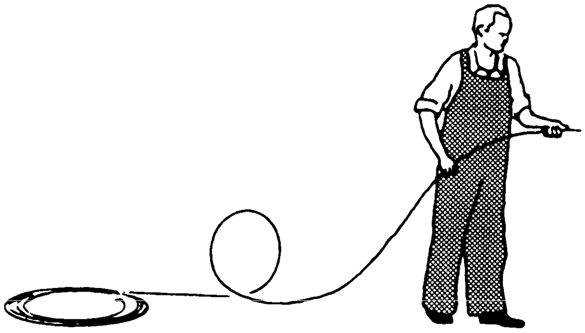


Figure 13-10.—Improper handling.

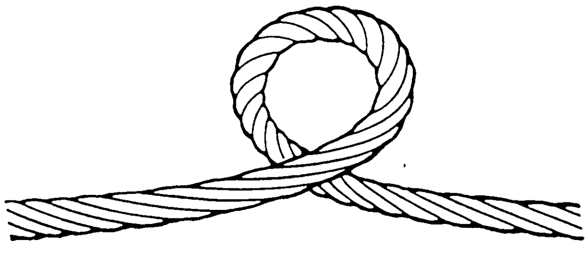


Figure 13-11.—Wire rope loop.

To uncoil a small coil of wire rope, simply stand the coil on edge and roll it along the ground like a wheel, or hoop, as also shown in figure 13-9. NEVER lay the coil flat on the floor or ground and uncoil it by pulling on the end, because such practice can kink or twist the rope.

Kinks

One of the most common forms of damage resulting from improper handled wire rope is the development of a kink. A kink starts with the formation of a loop, as shown in figures 13-10 and 13-11.

A loop that has not been pulled tight enough to set the wires or strands of the rope into a kink can be removed by turning the rope at either end in the proper direction to restore the lay, as shown in figure 13-12. If this is not done and the loop is pulled tight enough to cause a kink (fig. 13-13), the kink will result in irreparable damage to the rope (fig. 13-14).

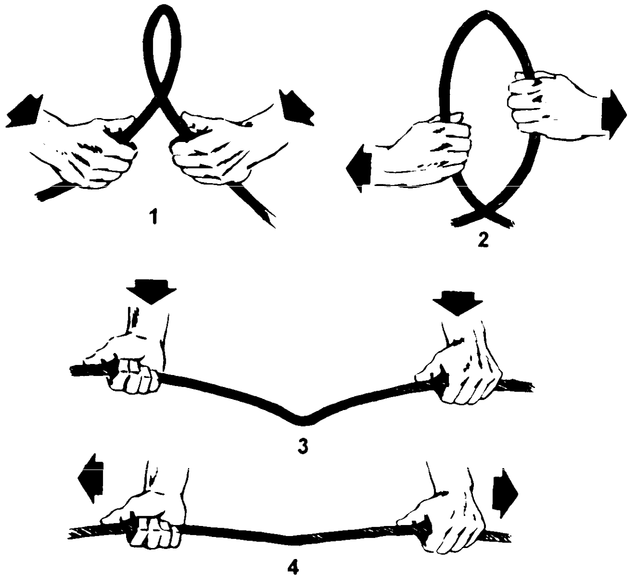


Figure 13-12.—The correct way to take out a loop in a wire rope.

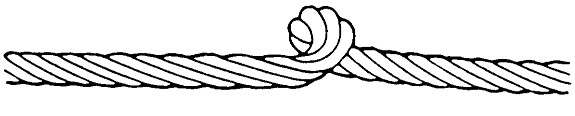


Figure 13-13.—Wire rope kink.

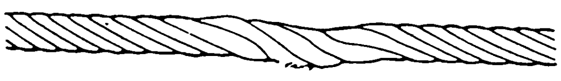


Figure 13-14.—Kink damage.

Kinking can be prevented by proper uncoiling and unreeling methods and by the correct handling of the rope throughout its installation.

Drum Winding

Spooling wire rope on a crane hoist drum causes a slight rotating tendency of the rope due to the spiral lay of the strands. Two types of hoist drums used for spooling wire rope are as follows:

1. Grooved drum. When grooved drums are used, the grooves generally give sufficient control to wind the wire rope properly, whether it is right or left lay rope.

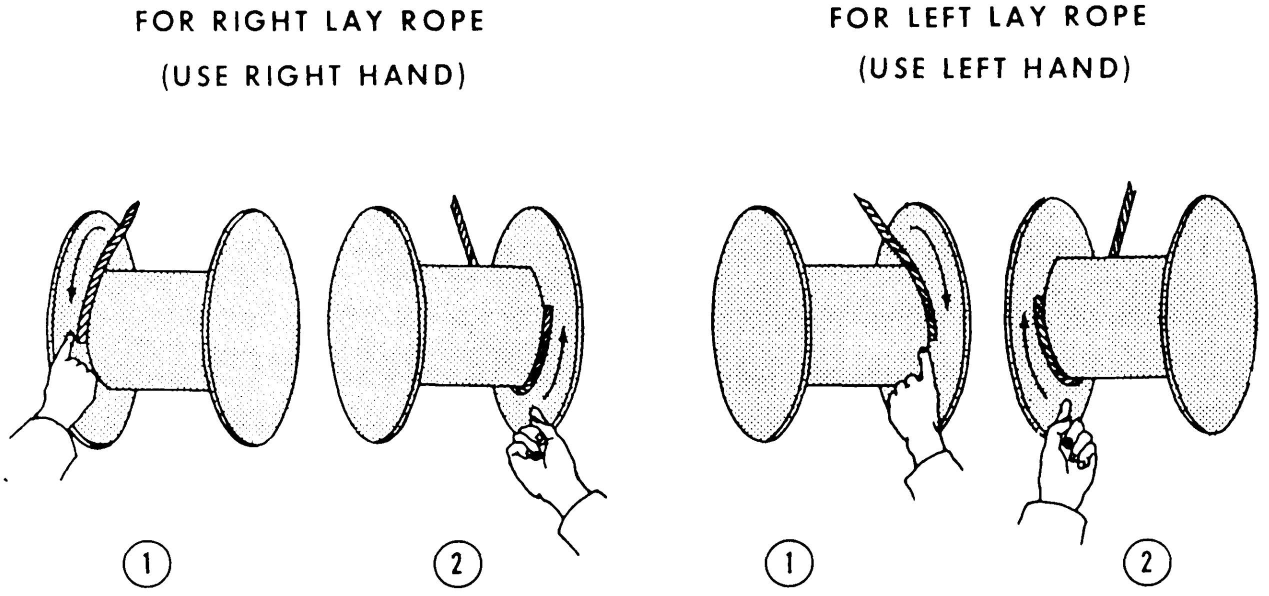
2, Smooth-faced drum. When smooth-faced drums are used, where the only other influence on the wire rope in winding on the first layer is the fleet angle, the slight rotational tendency of the rope can be used as an advantage in keeping the winding tight and uniform.

NOTE: Using the wrong type of wire rope lay causes the rotational tendency of the rope to be a disadvantage, because it results in loose and nonuniform winding of the rope on the hoist drum.

Figure 13-15 shows drum winding diagrams for selection of the proper lay of rope. Standing behind the hoist drum and looking toward an oncoming overwind rope, the rotating tendency of right lay rope is toward the left; whereas, the rotating tendency of a left lay rope is toward the right.

Refer to figure 13-15. With overwind reeving and a right lay rope on a smooth-faced drum, the wire rope bitter end attachment to the drum flange should be at the left flange. With underwind reeving and a right lay rope, the wire rope bitter end attachment should beat the right flange.

When wire rope is run off one reel onto another or onto a winch or drum, it should be run from **TOP TO**



FOR OVERWIND ON DRUM:

The palm is down, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the left-side flange.
The wind of the rope must be from left to right along the drum.

FOR UNDERWIND ON DRUM:

The palm is up, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the right-side flange.
The wind of the rope must be from right to left along the drum.

FOR OVERWIND ON DRUM:

The palm is down, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the right-side flange.
The wind of the rope must be from right to left along the drum.

FOR UNDERWIND ON DRUM:

The palm is up, facing the drum.
The index finger points at on-winding rope.
The index finger must be closest to the left-side flange.
The wind of the rope must be from left to right along the drum.

If a smooth-face drum has been cut or scored by an old rope, the methods shown may not apply.

Figure 13-15.—Different lays of wire rope winding on hoist drums.

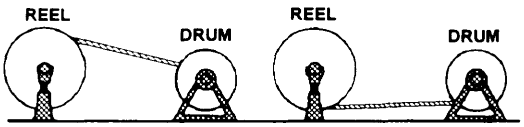

REEL
DRUM
REEL
DRUM

Figure 13-16.-Transferring wire rope from reel to drum.

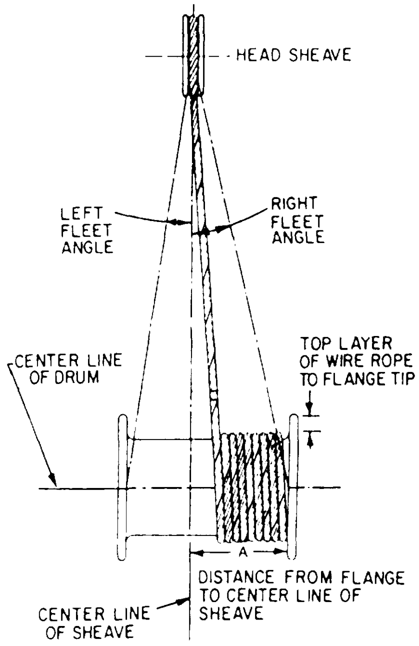

HEAD SHEAVE
LEFT FLEET ANGLE
RIGHT FLEET ANGLE
CENTER LINE OF DRUM
TOP LAYER OF WIRE ROPE TO FLANGE TIP
A
DISTANCE FROM FLANGE TO CENTER LINE OF SHEAVE
CENTER LINE OF SHEAVE

Figure 13-17.—Fleet angle relationship.

TOP or from **BOTTOM TO BOTTOM,** as shown in figure 13-16.

Fleet Angle

The fleet angle is formed by running wire rope between a sheave and a hoist drum whose axles are parallel to each other, as shown in figure 13-17. Too large a fleet angle can cause the wire rope to climb the flange of the sheave and can also cause the wire rope to climb over itself on the hoist drum.

Sizes of Sheaves

The diameter of a sheave should never be less than 20 times the diameter of the wire rope. An exception is 6 x 37 wire for which a smaller sheave can be used, because this wire rope is more flexible.

The chart shown in table 13-1 can be used to determine the minimum sheave diameter for wire rope of various diameters and construction.

Reverse Bends

Whenever possible, drums, sheaves, and blocks used with wire rope should be placed to avoid reverse or S-shaped bends. Reverse bends cause the individual wires or strands to shift too much and increase wear and fatigue. For a reverse bend, the drums and blocks affecting the reversal should be of a larger diameter than

Table 13-1.–Suggested Minimum Tread Diameter of Sheaves and Drums

Rope diameter in inches	Minimum tread diameter in inches for given rope construction*			
	6 x 7	6 x 19	6 x 37	8 x 19
1/4	10 1/2	8 1/2	---	6 1/2
3/8	15 3/4	12 3/4	6 3/4	9 3/4
1/2	21	17	9	13
5/8	26 1/4	21 1/4	11 1/4	16 1/4
3/4	31 1/2	25 1/2	13 1/2	19 1/2
7/8	36 3/4	29 3/4	15 3/4	22 3/4
1	42	34	18	26
1 1/8	47 1/4	38 1/4	20 1/2	29 1/4
1 1/4	52 1/2	42 1/2	22 1/2	32 1/2
1 1/2	63	51	27	39

Rope construction

Sheave diameter

*Rope construction is in strands times wires per strand.

ordinarily used and should be spaced as far apart as possible.

Seizing and Cutting

The makers of wire rope are careful to lay each wire in the strand and each strand in the rope under uniform tension. If the ends of the rope are not secured properly, the original balance of tension will be disturbed and maximum service cannot be obtained because some strands can carry a greater portion of the load than others. Before cutting steel wire rope, place seizing on each side of the point where the rope is to be cut (fig. 13-18).

A rule of thumb for determining the size, number, and distance between seizing is as follows:

1. The number of seizing to be applied equals approximately three times the diameter of the rope.

Example: 3 x 3/4-inch-diameter rope = 2 1/4 inches. Round up to the next higher whole number and use three seizing.

2. The width of each seizing should be 1 to 1 1/2 times as long as the diameter of the rope.

Example: 1 x 3/4-inch-diameter rope = 3/4 inch. Use a 1-inch width of seizing.

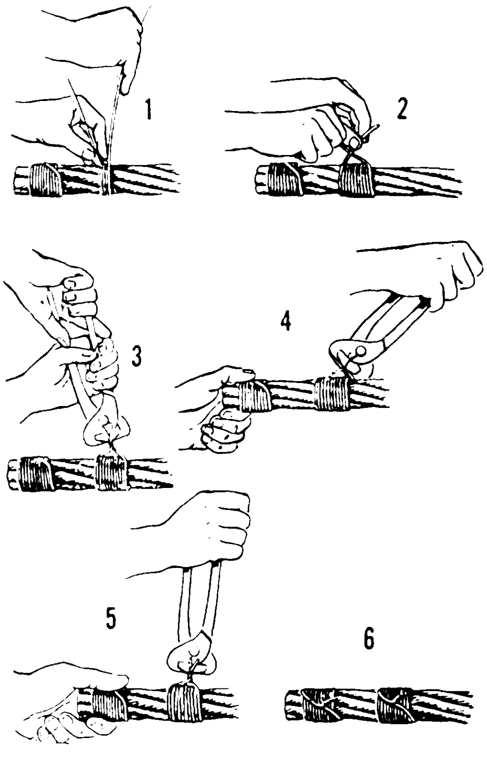


Figure 13-18.-Seizing wire rope.

3. The seizing should be spaced a distance equal to twice the diameter of the wire rope.

Example: 2 x 3/4-inch-diameter rope = 1 1/2 inches. Space the seizing 2 inches apart.

A common method used to make a temporary wire rope seizing is as follows:

Wind on the seizing wire uniformly, using tension on the wire. After taking the required number of turns, as shown in step 1, twist the ends of the wires counterclockwise by hand, so the twisted portion of the wires is near the middle of the seizing, as shown in step 2. Grasp the ends with end-cutting nippers and twist up slack, as shown in step 3. Do not try to tighten the seizing by twisting. Draw up on the seizing, as shown in step 4. Again twist up the slack, using nippers, as shown in step 5. Repeat steps 4 and 5 if necessary. Cut ends and pound them down on the rope, as shown in step 6. If the seizing is to be permanent or if the rope is 1 5/8 inches or more in diameter, use a serving bar, or iron, to increase tension on the seizing wire when putting on the turns.

Wire rope can be cut successfully by a number of methods. One effective and simple method is to use a hydraulic type of wire rope cutter, as shown in figure 13-19. Remember that all wire should be seized before it is cut. For best results in using this method, place the rope in the cutter so the blade comes between the two central seizings. With the release valve closed, jack the blade against the rope at the location of the cut and continue to operate the cutter until the wire rope is cut.

MAINTENANCE OF WIRE ROPE

Wire rope bending around hoist drums and sheaves will wear like any other metal article, so lubrication is just as important to an operating wire rope as it is to any other piece of working machinery. For a wire rope to

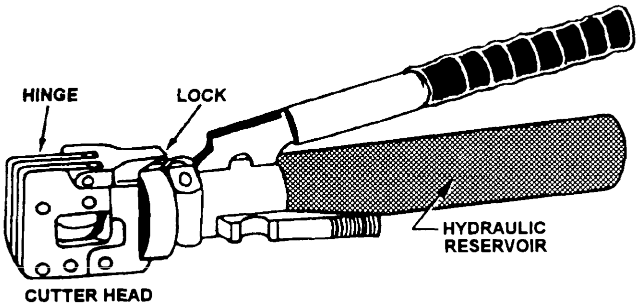


Figure 13-19.—Hydraulic type of wire rope cutter.

work right, its wires and strands must be free to move. Friction from corrosion or lack of lubrication shortens the service life of wire rope.

Deterioration from corrosion is more dangerous than that from wear, because corrosion ruins the inside wires—a process hard to detect by inspection. Deterioration caused by wear can be detected by examining the outside wires of the wire rope, because these wires become flattened and reduced in diameter as the wire rope wears.

NOTE: Replace wire rope that has wear of one third of the original diameter of the outside individual wires.

Both internal and external lubrication protects a wire rope against wear and corrosion. Internal lubrication can be properly applied only when the wire rope is being manufactured, and manufacturers customarily coat every wire with a rust-inhibiting lubricant, as it is laid into the strand. The core is also lubricated in manufacturing.

Lubrication that is applied in the field is designed not only to maintain surface lubrication but also to prevent the loss of the internal lubrication provided by the manufacturer. The Navy issues an asphaltic petroleum oil that must be heated before using. This lubricant is known as **Lubricating Oil for Chain, Wire Rope, and Exposed Gear** and comes in two types:

- Type I, Regular: Does not prevent rust and is used where rust prevention is not needed; for example, elevator wires used inside are not exposed to the weather but need lubrication.

- Type II, protective: A lubricant and an anti-corrosive— it comes in three grades: grade A, for cold weather (60°F and below); grade B, for warm weather (between 60°F and 80°F); and grade C, for hot weather (80°F and above).

The oil, issued in 25-pound and 35-pound buckets and in 100-pound drums, can be applied with a stiff brush, or the wire rope can be drawn through a trough of hot lubricant, as shown in figure 13-20. The frequency of application depends upon service conditions; as soon as the last coating has appreciably deteriorated, it should be renewed.

CAUTION

Avoid prolonged skin contact with oils and lubricants. Consult the Materials Safety Data Sheet (MSDS) on each item before use for precautions and hazards. See your supervisor for copies of MSDSs.

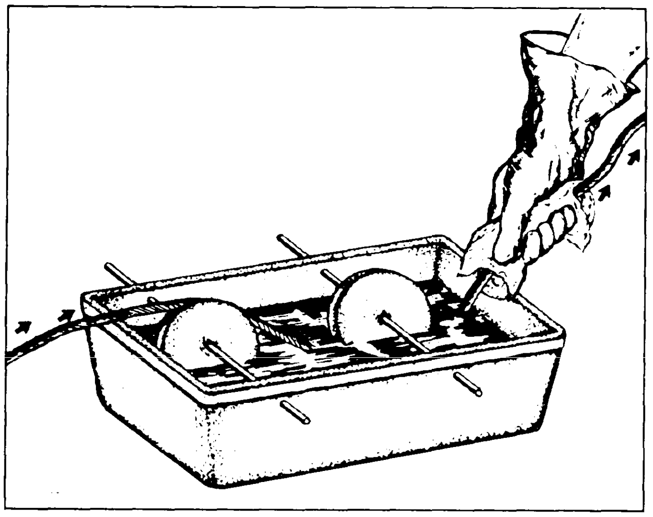


Figure 13-20.—Trough method of lubricating wire rope.

A good lubricant to use when working in the field, as recommended by COMSECOND/COMTHIRD-NCBINST 11200.11, is a mixture of new motor oil and diesel fuel at a ratio of 70-percent oil and 30-percent diesel fuel. The NAVFAC P-404 contains added information on additional lubricants that can be used.

Never lubricate wire rope that works a dragline or other attachments that normally bring the wire rope in contact with soils. The reason is that the lubricant will pick up fine particles of material, and the resulting abrasive action will be detrimental to both the wire rope and sheave.

As a safety precaution, always wipe off any excess oil when lubricating wire rope especially with hoisting equipment. Too much lubricant can get into brakes or clutches and cause them to fail. While in use, the motion of machinery may sling excess oil around over crane cabs and onto catwalks making them unsafe.

NOTE: Properly dispose of wiping rags and used or excess lubricant as hazardous waste. See your supervisor for details on local disposal requirements.

WIRE ROPE ATTACHMENTS

Many attachments can be fitted to the ends of wire rope, so the rope can be connected to other wire ropes, pad eyes, or equipment.

Wedge Socket

The attachment used most often to attach dead ends of wire ropes to pad eyes or like fittings on cranes and

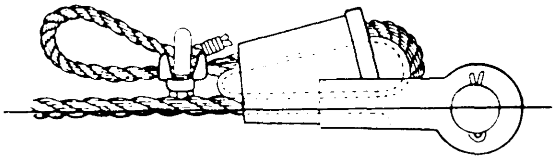


Figure 13-21.—Wedge socket.

earthmoving equipment is the wedge socket, as shown in figure 13-21. The socket is applied to the bitter end of the wire rope.

NOTE: The wedge socket develops only 70% of the breaking strength of the wire rope due to the crushing action of the wedge.

Speltered Socket

Speltering is the best way to attach a closed or open socket in the field. **"Speltering"** means to attach the socket to the wire rope by pouring hot zinc around it, as shown in figure 13-22. Speltering should only be done by qualified personnel.

Forged steel speltered sockets are as strong as the wire rope itself; they are required on all cranes used to lift personnel, ammunition, acids, and other dangerous materials.

NOTE: Spelter sockets develop 100% of the breaking strength of the wire rope.

Wire Rope Clips

Wire rope clips are used to make eyes in wire rope, as shown in figure 13-23. The U-shaped part of the clip with the threaded ends is called the **U-bolt;** the other part is called the **saddle.** The saddle is stamped with the diameter of the wire rope that the clip will fit. Always place a clip with the U-bolt on the bitter (dead) end, not on the standing part of the wire rope. If clips are attached incorrectly, the standing part (live end) of the wire rope will be distorted or have mashed spots. A rule of thumb when attaching a wire rope clip is to NEVER saddle a dead horse.

Two simple formulas for figuring the number of wire rope clips needed are as follows:

3 x wire rope diameter + 1 = Number of clips

6 x wire rope diameter = Spacing between clips

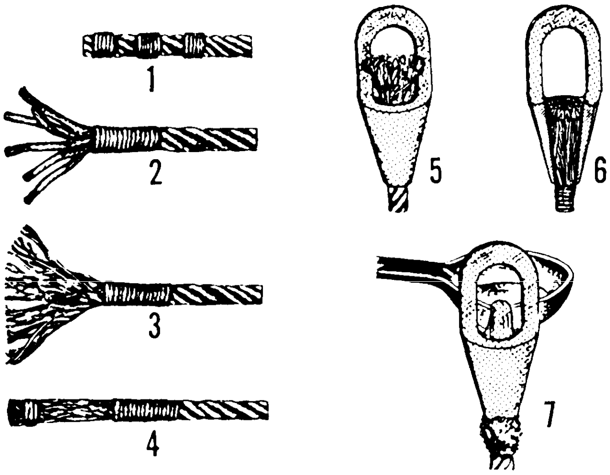


Figure 13-22.—Speltering a socket.

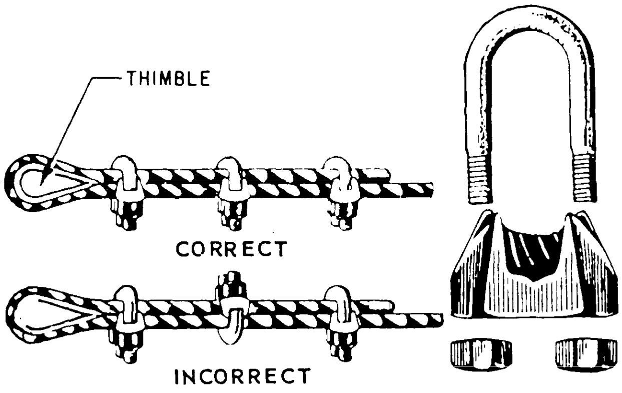


Figure 13-23.—Wire rope clips.

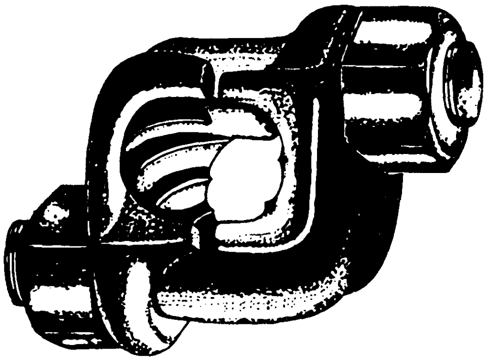


Figure 13-24.—Twin-base wire rope clip.

Another type of wire rope clip is the twin-base clip, often referred to as the universal or two clamp, as shown in figure 13-24. Both parts of this clip are shaped to fit the wire rope, so the clip cannot be attached incorrectly. The twin-base clip allows for a clear 360-degree swing with the wrench when the nuts are being tightened.

Thimble

When an eye is made in a wire rope, a metal fitting, called a **thimble,** is usually placed in the eye, as shown in figure 13-23. The thimble protects the eye against wear. Wire rope eyes with thimbles and wire rope clips can hold approximately 80 percent of the wire rope strength.

After the eye made with clips has been strained, the nuts on the clips must be retightened. Checks should be made now and then for tightness or damage to the rope caused by the clips.

Swaged Connections

Swaging makes an efficient and permanent attachment for wire rope, as shown in figure 13-25. A swaged connection is made by compressing a steel sleeve over the rope by using a hydraulic press. When the connection is made correctly, it provides 100-percent capacity of the wire rope.

Careful inspection of the wires leading into these connections are important because of the pressure put upon the wires in this section. If one broken wire is found at the swaged connection or a crack in the swage, replace the fitting.

Hooks and Shackles

Hooks and shackles are handy for hauling or lifting loads without tying them directly to the object with a line, wire rope, or chain. They can be attached to wire rope, fiber line, blocks, or chains. Shackles should be used for loads too heavy for hooks to handle.

When hooks fail due to overloading, they usually straighten out and lose or drop their load. When a hook has been bent by overloading, it should NOT be straightened and put back into service; it should be cut in half with a cutting torch and discarded.

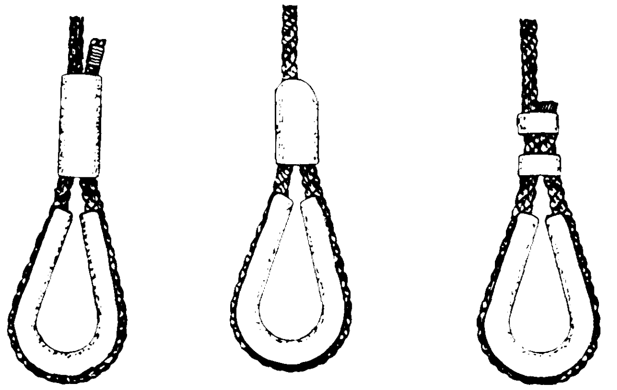


Figure 13-25.-Swaged connections.

Hooks should be inspected at the beginning of each workday and before lifting a full-rated load. If you are not sure a hook is strong enough to lift the load, by all means use a shackle.

Hooks that close and lock should be used where there is danger of catching on an obstruction, particularly in hoisting buckets, cages, or skips, and especially in shaft work. Hooks and rings used with a chain should have about the same strength as the chain.

The manufacturers' recommendations should be followed in determining the safe working loads of the various sizes and types of specific and identifiable hooks. All hooks for which no applicable manufacturers' recommendations tire available should be tested to twice the intended safe working load before they are initially put into use.

Mousing is a technique often used to close the open section of a hook to keep slings, straps, and similar attachments from slipping off the hook, as shown in figure 13-26.

Hooks may be moused with rope yarn, seizing wire, or a shackle. When using rope yarn or wire, make 8 or 10 wraps around both sides of the hook. To finish off, make several turns with the yarn or wire around the sides of the mousing, and then tie the ends securely.

Two types of shackles used in rigging are the **anchor** (Fig. 13-27) and the **chain** (fig. 13-28). Both are available with screw pins or round pins.

Shackles should be used in the same configuration as they were manufactured. Never replace the shackle pin with a bolt. when the original pin is lost or does not fit properly, do not use the shackle. All pins must be straight and cotter pins must be used or all screw pins must be seated.

A shackle should never be pulled from the side, because this causes the shackle to bend which reduces the capacity tremendously. Always attach a screw pin

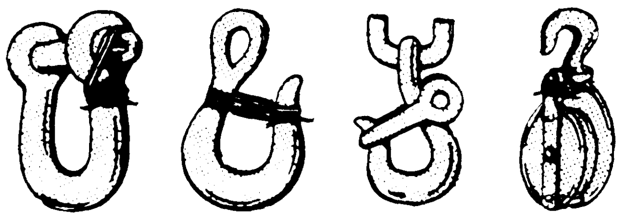


Figure 13-26.—Mousing.

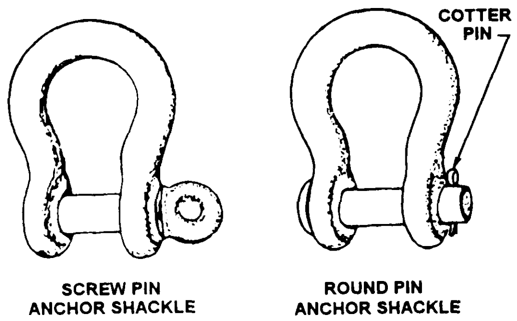


Figure 13-27.—Anchor shackles.

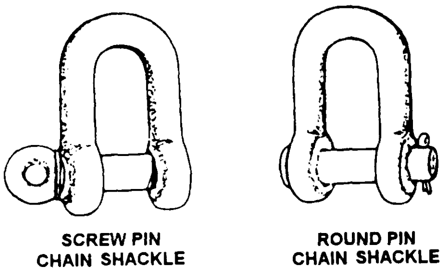


Figure 13-28.—Chain shackles.

shackle with the screw pin on the dead end of the rope. If placed on the running end, the movement of the rope may loosen the pin.

Shackles are moused whenever there is a chance of the shackle pin working loose and coming out because of vibration. To mouse a shackle, simply take several turns with seizing wire through the eye of the pin and around the bow of the shackle. Figure 13-26 shows what a properly moused shackle looks like.

FIBER LINE

Fiber line is commonly used to hoist and move heavy loads. Fiber line is constructed similar to wire rope. One difference is yarn. Yarn is used to make the strand in place of wire. Another difference is fiber line does not have a core.

TYPES OF FIBER LINE

The most common types of fiber line are manila, sisal, hemp, cotton, nylon, and Kevlar. The characteristics of these fiber lines are discussed below.

Manila

Manila is a strong fiber that comes from the leaf stems of the stalk of the abaca plant, which belongs to the banana family. The fibers vary in length from 1.2 to 4.5 meters in the natural state. The quality of the fiber and its length give manila rope relatively high elasticity, strength, and resistance to wear and deterioration. In many instances, the manufacturer treats the rope with chemicals to make it more mildew resistant, which increases the quality of the rope. Manila rope is generally the standard item of issue because of its quality and relative strength.

Sisal

Sisal rope is made from two tropical plants that yield a strong, valuable fiber. These plants, sisalana and henequen, produce fibers 0.6 to 1.2 meters long with sisalana producing the stronger fibers of the two plants. Because of the greater strength of sisalana, these fibers are used to make the rope known as sisal. Sisal rope is about 80 percent as strong as high-quality manila rope and can be easily obtained. It withstands exposure to seawater very well and is often used for this reason.

Hemp

Hemp is a tall plant that provides useful fibers for making rope and cloth. Cultivated in many parts of the world, hemp was used extensively before the introduction of manila. Its principal use now is in fittings, such as ratline, marline and spun yarn. Since hemp absorbs tar much better than the hard fibers, these fittings are invariably tarred to make them water resistant. Tarred hemp has about 80 percent of the strength of untarred hemp. Of these tarred fittings, marline is the standard item of issue.

Cotton

Cotton rope is a very smooth white rope that stands much bending and running. Cotton is not widely used in the Navy except in some cases for small lines.

Nylon

Nylon rope has a tensile strength that is nearly three times that of manila rope. The advantage of using nylon rope is that it is waterproof and has the ability to resume normal length after being stretched and/or absorbing shocks. It also resists abrasion, rot, decay, and fungus

When nylon rope is properly handled and maintained, it should last more than five times longer than manila line subjected to the same use. Nylon rope is also lighter, more flexible, less bulky, and easier to handle and store than manila line. When nylon rope is wet or frozen, it loses little strength. Additionally, nylon line defies mildew, rotting, and attack by marine borers.

Nylon rope can hold a load even when many strands are abraded. Normally, when abrasion is local, the rope may be restored to use by cutting away the chafed section and splicing the ends. Chafing, and stretching do not necessarily affect the load-carrying ability of nylon rope.

The splicing of nylon rope is very similar to that of manila; however, friction tape is used instead of seizing stuff for whipping the strands and line. Because it is smooth and elastic, nylon requires at least one tuck more than manila. For heavy loads, a back tuck should be taken with each strand.

As with manila, nylon rope is measured by circumference. Nylon, as manila, usually comes on a reel of 600 to 1,200 feet, depending upon the size. Do not uncoil new nylon rope by pulling the ends up through the eye of the coil. Unreel it as you would wire rope. Avoid coiling nylon in the same direction all the time, or you could unbalance the lay.

When nylon rope is stretched more than 40 percent, it is likely to part. The stretch is immediately recovered with a snapbaak that sounds like a pistol shot.

WARNING

> The snapback of a nylon rope can be as deadly as a bullet. Make sure no one stands in the direct line of pull when a heavy strain is applied.

This feature is also true for other types of lines, but overconfidence in the strength of nylon may lead one to underestimate its backlash.

The critical point of loading is 40-percent extension of length; for example, a 10-foot length of nylon rope would stretch to 14 feet when under load. Should the stretch exceed 40 percent, the linc will be in danger of parting.

If a nylon rope becomes slippery because of grease, it should be cleaned with a light oil, such as kerosene or diesel oil.

Do not store nylon line in strong sunlight. Cover it with tarpaulins. In storage, keep it away from heat and strong chemicals.

Kevlar

Kevlar is most popularly used to make bulletproof vests and knifeproof gloves. The characteristics of Kevlar line are similar to those of Nylon line except for one significant difference—Kevlar line does not snapback when it parts. This is an important safety feature, since parted nylon line has resulted in numerous deaths due to violent snapbacks.

HANDLING AND CARE OF FIBER LINE

If you expect the fiber line you work with to give safe and dependable service, make sure it is handled and cared for properly. Procedures for handling and caring of fiber line arc as follows:

- CLEANLINESS is part of the care of fiber line. NEVER drag a line over the ground or over rough or dirty surfaces. The line can easily pickup sand and grit that can work into the strands and wear the fibers. If a line dots get dirty, use water only to clean it. **Do NOT** use soap, because it takes oil out of the line.

- AVOID pulling a line over sharp edges because the strands may break. When you have a sharp edge, place chafing gear, such as a board, folded cardboard or canvas, or part of a rubber tire, between the line and the sharp edge to prevent damaging the line.

- NEVER cut a line unless you have to. When possible, always use knots that can be untied easily.

Fiber line will contract or shrink if it gets wet. If there is not enough slack in a wet line to permit shrinkage, the line is likely to overstrain and weaken. If a taut line is exposed to rain or dampness, make sure that the line, while still dry, is slackened to allow for the shrinkage.

INSPECTION OF FIBER LINE

Line should be inspected carefully at regular intervals to determine if it is safe. The outside of a line does not show the condition of the line on the inside. Untwisting the strands slightly allows you to check the condition of the line on the inside. Mildewed line gives off a musty odor. Broken strands, or yarns, usually can be spotted immediately by a trained observer. You want to look carefully to ensure there is no dirt or sawdust-like materia] inside the line. Dirt or other foreign matter inside reveals possible damage to the internal structure of the line. A smaller circumference of the line is usually a sure sign that too much strain has been applied to the line.

For a thorough inspection, a line should be examined at several places. After all, only one weak spot, anywhere in a line, makes the entire line weak. As a final check, pull out a couple of fibers from the line and try to break them. **Sound fibers** have a strong

If an inspection discloses any unsatisfactory conditions in a line, see that the line is destroyed or cut into small pieces as soon as possible. This precaution prevents the defective line from being used for hoisting.

CHAIN

In the NCF, never use a chain when it is possible to use wire rope. The reason for this is because, unlike wire rope, chain does not have reserve strength and does not give any warning that it is about to fail; therefore, you will not be alerted of a potentially hazardous condition.

Chain is better suited than wire rope for some jobs because it is more resistant to abrasion, corrosion, and heat. When chain is used as a sling, it has no flexibility and grips the load well.

CHAIN GRADES

It is difficult to determine the grade of some types of chains by looking at them. Most chains used by the NCF are class A chain. If you are uncertain of the class or size of a chain, ask your supervisor.

CHAIN STRENGTH

Before lifting with a chain, make sure the chain is free from twists and kinks. A twisted or kinked chain placed under stress could fail even when handling a light load. Additionally, ensure that the load is properly seated in the hook (not on the point) and that the chain is free from nicks or other damage. Avoid sudden jerks in lifting and lowering the load, and always consider the angle of lift with a sling chain bridle.

The strength of any chain will be affected when it has been knotted, overloaded, or heated to temperatures above 500°F.

HANDLING AND CARE OF CHAIN

When hoisting heavy metal objects using chain for slings, you should insert padding around the sharp corners of the load to protect the chain links from being cut.

Store chains in a clean, dry place where they will not be exposed to the weather. Before storage, apply a light coat of lubricant to prevent rust.

Do NOT perform makeshift repairs, such as fastening links of a chain together with bolts or wire. When links become worn or damaged, cut them out of the chain, then fasten the two nearby links together with a connecting link. After the connecting link is closed, welding makes it as strong as the other links. For cutting small-sized chain links, use bolt cutters. To cut large-sized links, use a hacksaw.

Inspect the chain to ensure it is maintained in a safe, operating condition. A chain used continuously for heavy loading should be inspected frequently. Chain is less reliable than manila or wire rope slings because the links may crystallize and snap without warning.

Examine the chain closely link by link and look for stretch, wear, distortion, cracks, nicks, and gouges. Wear will usually be at the ends of the links where joining links rub together. If you find wear, lift each link and measure its cross section.

NOTE: Remove chains from service when any link shows wear more than 25 percent of the thickness of the metal.

Replace any link that shows cracks, distortion, nicks, or cuts; however, if a chain shows stretching or distortion of more than 5 percent in a five-link section, discard and destroy the entire chain.

Remove chains from service when links show any signs of binding at the juncture points of the links. This condition indicates collapse in the sides of the links has occurred as a result of stretching.

Before lifting with a chain, first place dunnage between the chain and the load to provide a gripping surface. For hoisting heavy metal objects with a chain, always use chafing gear around the sharp corners on the load to protect the chain links from being cut. As chafing gear, use either planks or heavy fabric. In handling rails or a number of lengths of pipe, make a round turn and place the hook around the chain, as shown in figure 13-29.

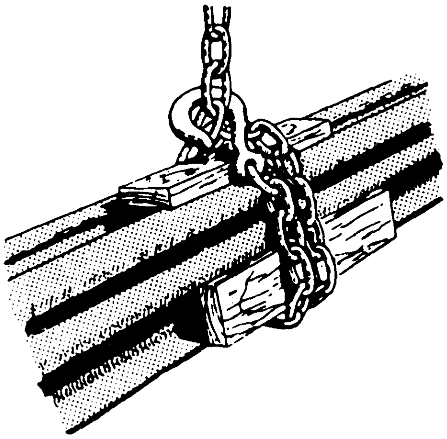


Figure 13-29.—Chain sling.

SLINGS

Slings are widely used for hoisting and moving heavy loads. Some types of slings come already made. Slings may be made of wire rope, fiber line, or chain.

SLINGS AND RIGGING GEAR KITS

The NCF has slings and rigging gear in the battalion Table of Allowance to support the rigging operations and the lifting of CESE. The kits 80104, 84003, and 84004 must remain in the custody of the supply officer in the central toolroom (CTR). The designated embarktion staff and the crane test director monitor the condition of the rigging gear. The crane crew supervisor normally has the responsibility to inventory the contents of the kits. The rigging kits must be stored undercover.

WIRE ROPE SLINGS

Wire rope slings offer advantantges of both strength and flexibility. These qualities make wire rope adequate to meet the requirements of most crane hoisting jobs; therefore, you will use wire rope slings more frequently than fiber line or chain slings.

FIBER LINE SLINGS

Fiber line slings are flexible and protect the finished material more than do wire rope sliings. But fiber line slings are not as strong as wire rope or chain slings. Also, fine line is more likely to be damaged by sharp edges on the material being hoisted than wire rope or chain slings.

CHAIN SLINGS

Chain slings are frequently used for hoisting heavy steel items, such as rails, pipes, beams, and angles. They are also handy for slinging hot loads and handling loads with sharp edges that might cut the wire rope.

USING WIRE ROPE AND FIBER LINE SLINGS

Three types of fiber line and wire rope slings commonly used for lifting a loud are the endless, single leg, and bridle slings.

An **endless sling,** usually referred to by the term **sling,** can be made by splicing the ends of a piece of fiber line or wire rope to form an endless loop. An endless sling is easy to handle and can be used as a **choker hitch** (fig. 13-30).

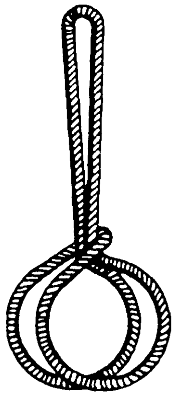


Figure 13-30.—Endless sling rigged as a choker hitch.

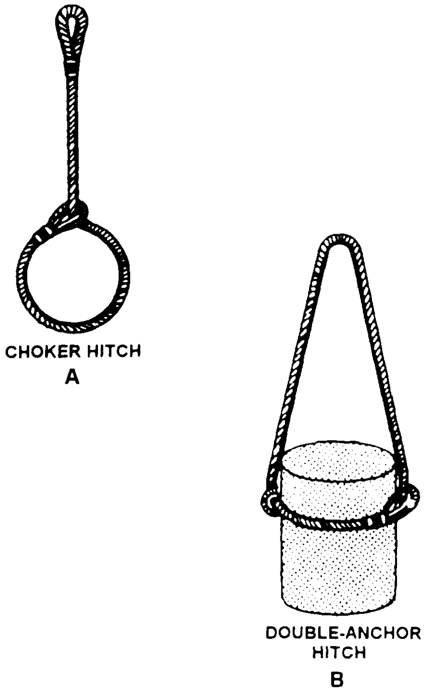


Figure 13-31.—Methods of using single-leg slings.

A **single-leg sling,** commonly referred to as a **strap,** can be made by forming a spliced eye in each end of a piece of fiber line or wire rope. Sometimes the ends of a piece oe wire rope are spliced into eyes around thimbles, and one eye is fastened to a hook with a shackle. With this arrangement, the shackle and hook are removable.

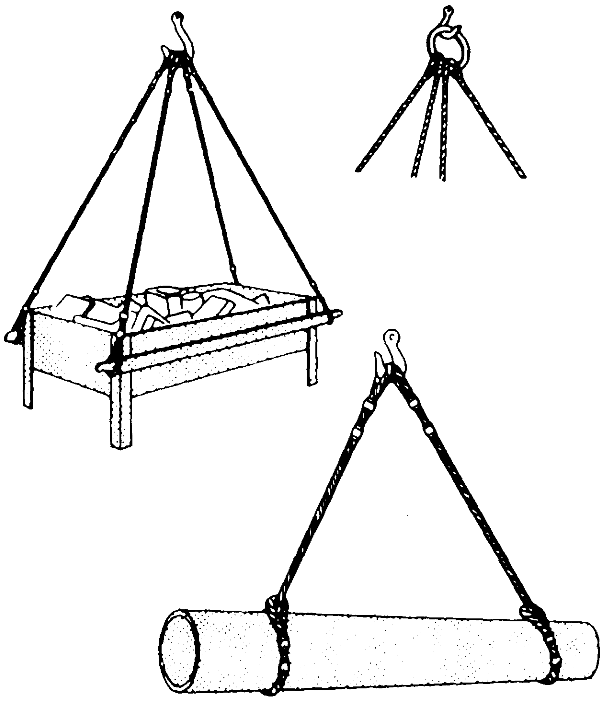


Figure 13-32.—Multi-legged bridle slings.

The single-leg sling may be used as a choker hitch (fig. 13-31, view A) in hoisting by passing one eye through the other eye and over the hoisting hook. The single-leg sling is also useful as a double-anchor hitch (fig. 13-31, view B). The double-anchor hitch works well for hoisting drums or other cylindrical objects where a sling must tighten itself under strain and lift by friction against the sides of the object.

Single-leg slings can be used to make various types of **bridles.** Three common uses of bridles are shown in figure 13-32. Either two or more single slings may be used for a given combination.

The bridle hitch provides excellent load stability when the load ia distributed equally among each sling leg. The load hook is directly over the center of gravity of the load, and the load is raised level. The use of bridle slings requires that the sling angles be carefully determined to ensure that the individual legs are not overloaded.

NOTE: It is wrong to conclude that a three- or four-leg bridle will safely lift a load equal to the safe load on one leg multiplied by the number of legs. This is because there is no way of knowing that each leg is carrying its share of the load.

With a four-legged bridle sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two legs only balance it. COMSECOND/COMTHIRDNCB strongly recommend that the rated capacity for two-leg bridle slings listed in the COMSECOND/COMTHIRDNCBINST 11200.11 be used also as the safe working load for three- or four-leg bridle hitches.

When lifting heavy loads, you should ensure that the bottom of the sling legs is fastened to the load to prevent damage to the load. Many pieces of equipment have eyes fastened to them during the process of manufacture to aid in lifting. With some loads, though, fastening a hook to the eye on one end of each sling leg suffices to secure the sling to the load.

Use a protective pad when a fiber line or wire rope sling is exposed to sharp edges at the corners of a load. Pieces of wood or old rubber tires are fine for padding.

Sling Angle

When you are using slings, remember that the greater the angle from vertical, the greater the stress on the sling legs. This point is shown in figure 13-33.

The rated capacity of any sling depends on the size, the configuration, and the angles formed by the legs of the sling and the horizontal. A sling with two legs used to lift a 1,000-pound object will have 500 pounds of the load on each leg when the sling angle is 90 degrees. The load stress on each leg increases as the angle decreases; for example, if the sling angle is 30 degrees when lifting the same 1,000-pound object, the load is 1,000 pounds on each leg. Try to keep all sling angles greater than 45 degrees; sling angles approaching 30 degrees are considered extremely hazardous and must be avoided.

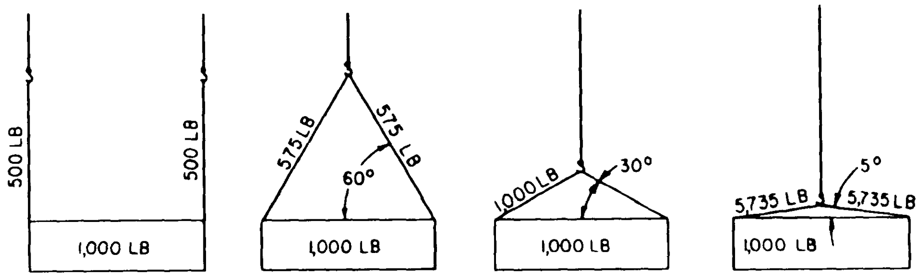


Figure 13-33.-Stress on slings at various vertical angles.

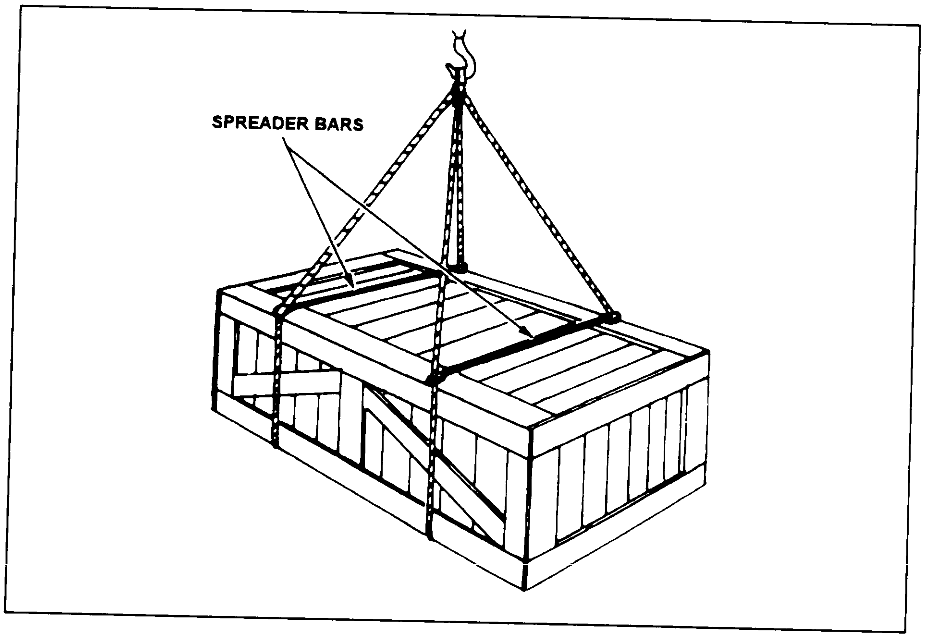

SPREADER BARS

Figure 13-34.—Using spreader bars.

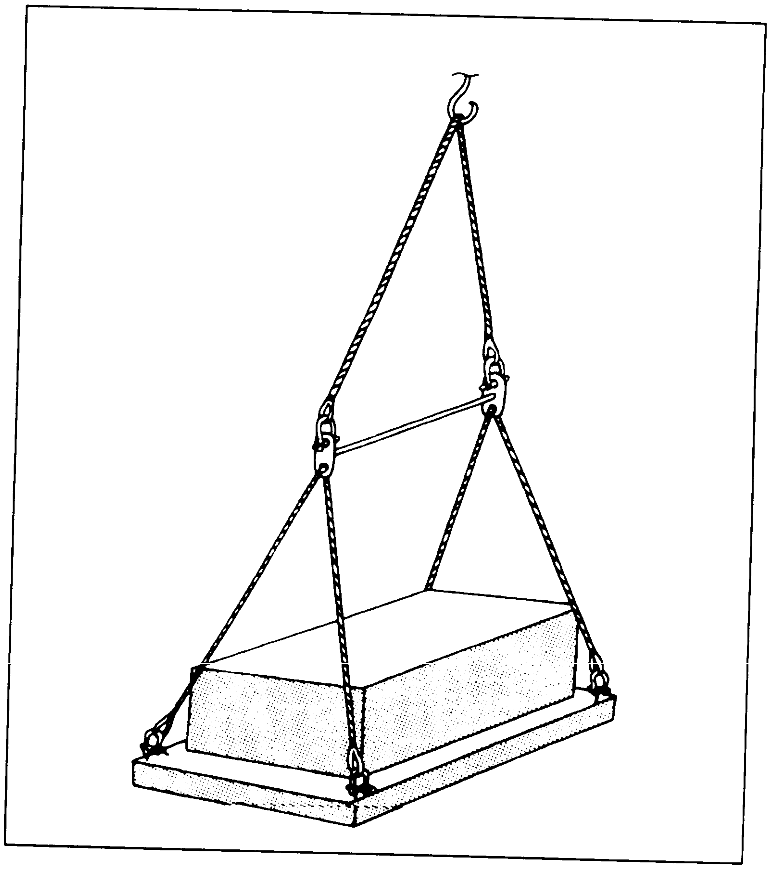
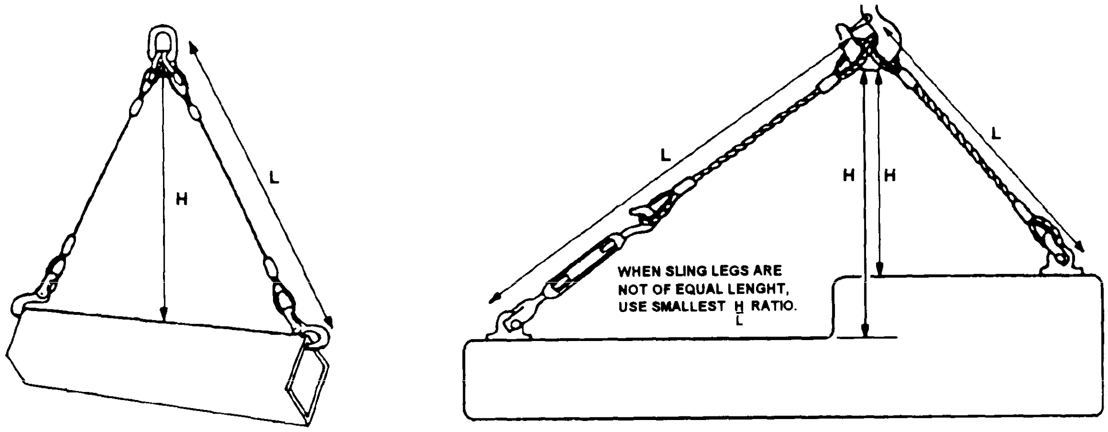
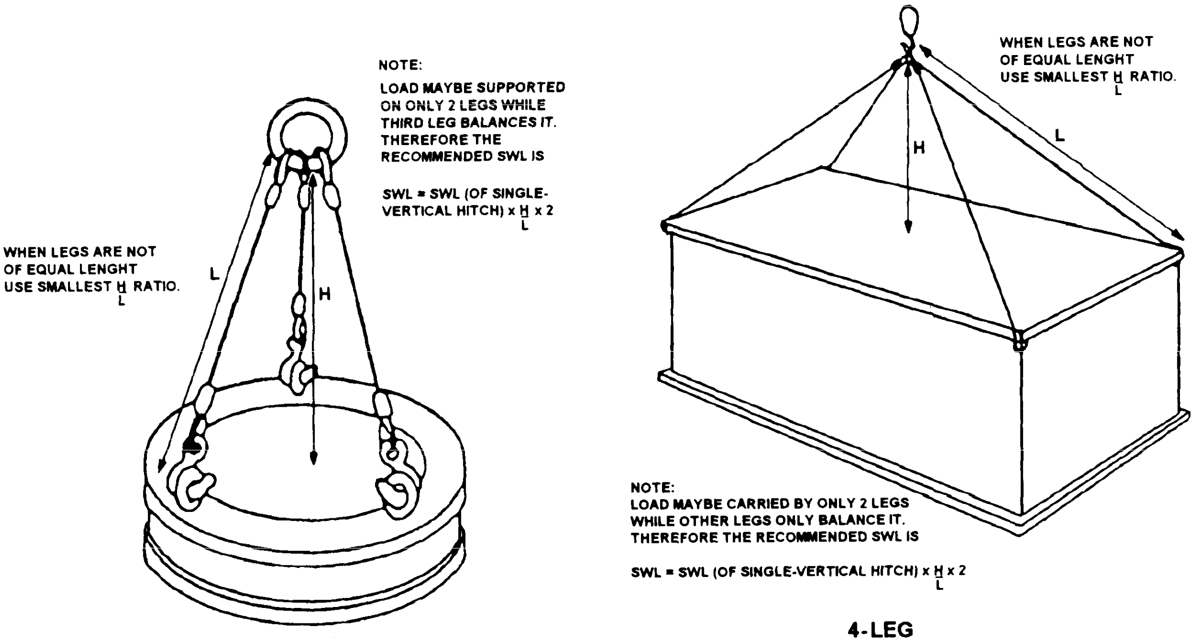


Figure 13-35.—Spreader bar used with an oversized load.


H
L
L
H
H
L
WHEN SLING LEGS ARE
NOT OF EQUAL LENGHT,
USE SMALLEST H/L RATIO.

2- LEG BRIDLE HITCHES


NOTE:
LOAD MAYBE SUPPORTED
ON ONLY 2 LEGS WHILE
THIRD LEG BALANCES IT.
THEREFORE THE
RECOMMENDED SWL IS
SWL = SWL (OF SINGLE-
VERTICAL HITCH) x H/L x 2
WHEN LEGS ARE NOT
OF EQUAL LENGHT
USE SMALLEST H/L RATIO.
L
H
WHEN LEGS ARE NOT
OF EQUAL LENGHT
USE SMALLEST H/L RATIO.
L
H
NOTE:
LOAD MAYBE CARRIED BY ONLY 2 LEGS
WHILE OTHER LEGS ONLY BALANCE IT.
THEREFORE THE RECOMMENDED SWL IS
SWL = SWL (OF SINGLE-VERTICAL HITCH) x H/L x 2

3-LEG

4-LEG

Figure 13-36.-Determination of bridle hitch sling capacity.

Spreaders Bars

In hoisting with slings, spreader bars are used to prevent crushing and damaging the load. Spreader bars are short bars, or pipes, with eyes fastened to each end. By setting spreader bars in the sling legs above the top of the load (fig. 13-34), you change the angle of the sling leg and avoid crushing the load particularly in the upper portion.

Spreader bars are also used in lifting long or oversized objects to control the sling angle, as shown in figure 13-35. When spreader bars are used, make sure you do not overload the end connection. A spreader bar has a rated capacity that is the same as hooks and shackles. A good rule of thumb is the thickness of the spreaders end connection should be the same as the thickness of the shackle pin.

Sling Safe Working Loads

Formulas for estimating the loads for most sling configurations have been developed. These formulas are based on the safe working load of the single-vertical hitch of a particular sling. The efficiencies of the end fittings used also have to be considered when determining the capacity of the combination.

The formula used to compute the safe working load (SWL) for a **bridle hitch** with two, three, or four legs (fig. 13-36) is SWL (of single-vertical hitch) times H (Height) divided by L (Length) times 2 = SWL. When

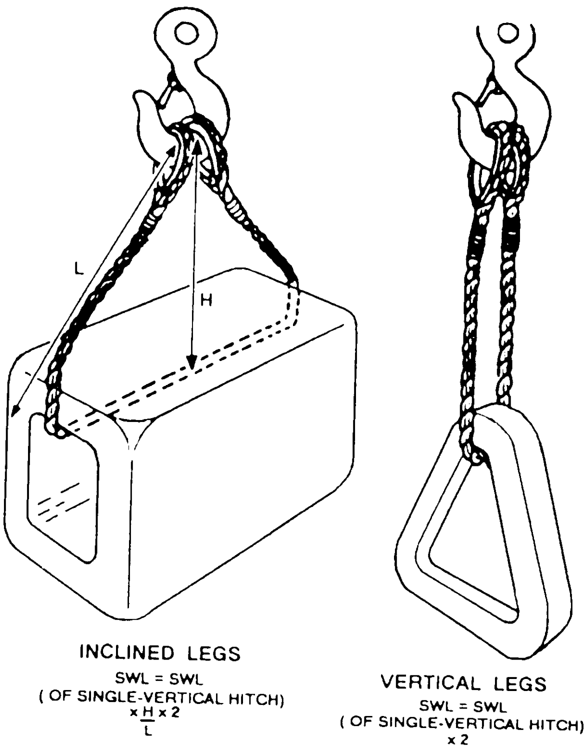

L
H
INCLINED LEGS
SWL = SWL
(OF SINGLE-VERTICAL HITCH)
x $\frac{H}{L}$ x 2
VERTICAL LEGS
SWL = SWL
(OF SINGLE-VERTICAL HITCH)
x 2

Figure 13-37.—Determination of single-basket hitch sling capacity.

the sling legs are not of equal length, use the smallest H/L measurement. This formula is for a two-leg bridle hitch, but it is strongly recommended that it also be used for the three- and four-leg hitches.

NOTE: Do NOT forget it is wrong to assume that a three- or four-leg hitch can safely lift a load equal to the safe load on one leg multiplied by the number of legs.

Other formulas are as follows:

Single-basket hitch (fig. 13-37): For vertical legs, SWL = SWL (of single-vertical hitch) x 2.

For inclined legs, SWL = SWL (of single-vertical hitch) x H divided by L x 4.

Double-basket hitch (fig. 13-38): For vertical legs, SWL = SWL (of single-vertical hitch) x 4.

For inclined legs, SWL = SWL (of single-vertical hitch) x H divided by L x 4.

Single-choker hitch (fig. 13-39): For sling angles of 45 degrees or more, SWL = SWL (of single-vertical hitch) x 3/4 or .75.

Sling angles of less than 45 degrees are not recommended; however, if they are used, the formula is SWL = SWL (of single-vertical hitch) x A/B.

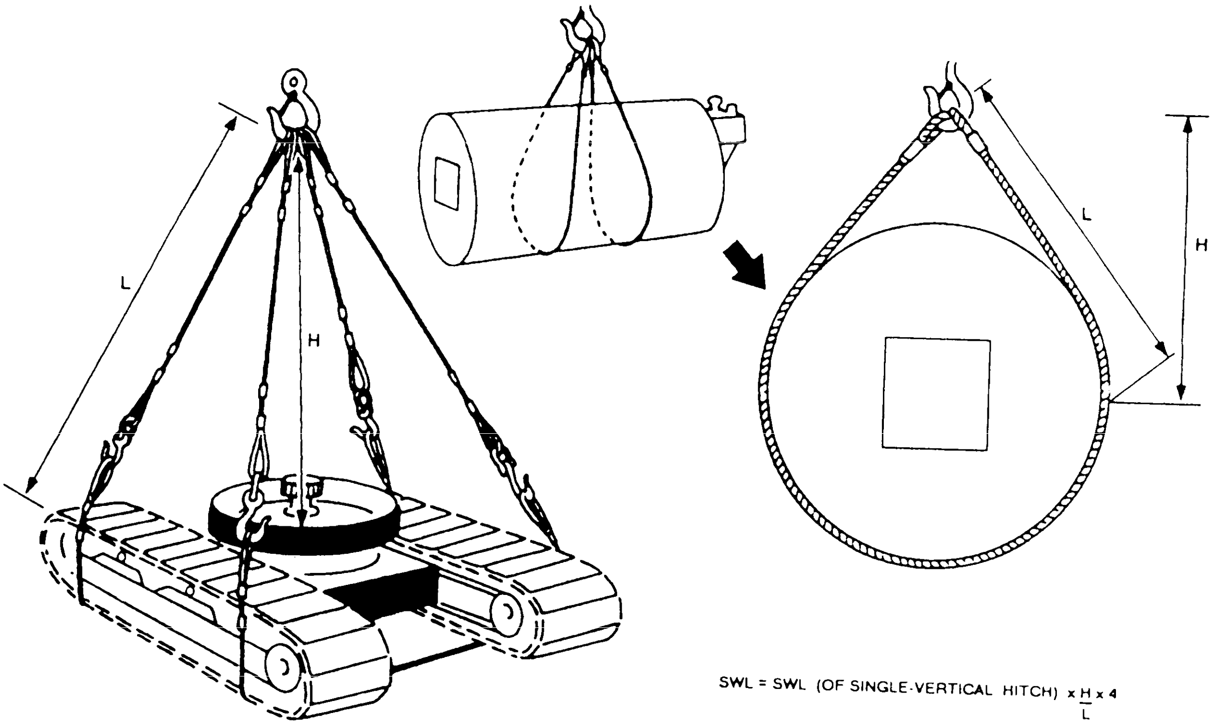

L
H
L
H
SWL = SWL (OF SINGLE-VERTICAL HITCH) x $\frac{H}{L}$ x 4

Figure 13-38.-Determination of double-basket hitch sling capacity.

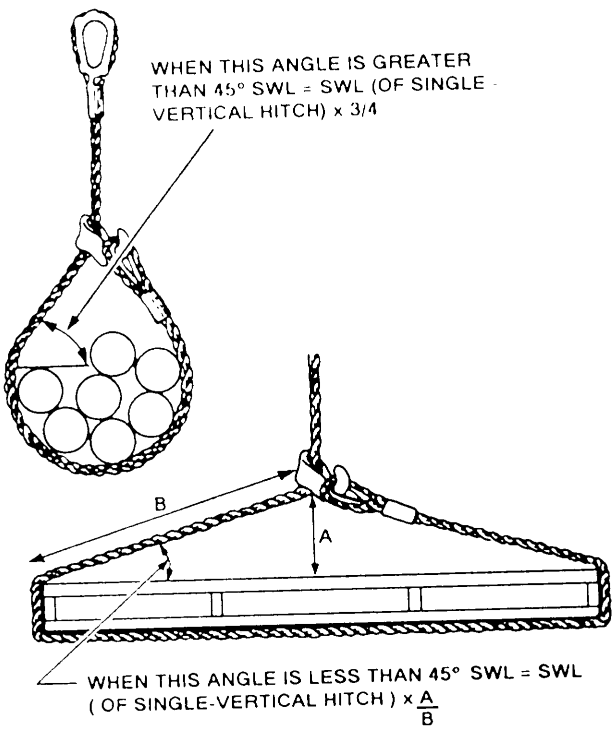

WHEN THIS ANGLE IS GREATER THAN 45° SWL = SWL (OF SINGLE VERTICAL HITCH) x 3/4
B
A
WHEN THIS ANGLE IS LESS THAN 45° SWL = SWL (OF SINGLE-VERTICAL HITCH) x A/B

Figure 13-39.—Determination of single-choker hitch sling

Double-choker hitch (fig. 13-40): For sling angle of 45 degrees or more, SWL = SWL (of single-vertical hitch) x 3 divided by 4 x H divided by L x 2.

Sling angles of less than 45 degrees, SWL = SWL (of single-vertical hitch) x A divided by B x H divided by L x 2.

Sling Inspection

All slings must be visually inspected for obvious unsafe conditions before each use. A determination to remove slings from service requires experience and good judgment, especially when evaluating the remaining strength in a sling after allowing for normal wear. The safety of the sling depends primarily upon the remaining strength. Wire rope slings must be immediately removed from service if any of the following conditions are present:

- Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay

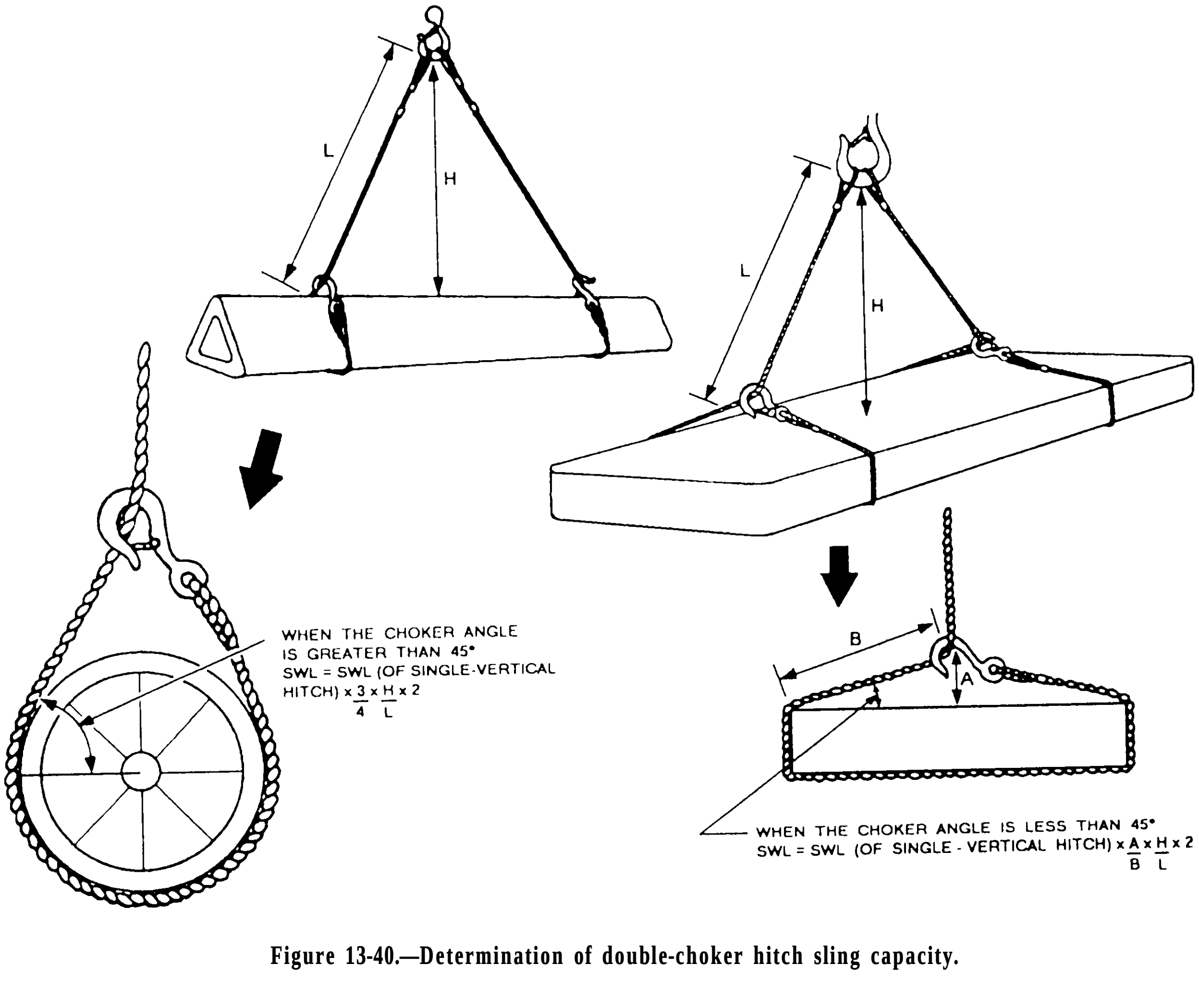

L
H
L
H
WHEN THE CHOKER ANGLE IS GREATER THAN 45° SWL = SWL (OF SINGLE-VERTICAL HITCH) x 3/4 x H/L x 2
B
A
WHEN THE CHOKER ANGLE IS LESS THAN 45° SWL = SWL (OF SINGLE - VERTICAL HITCH) x A/B x H/L x 2

Figure 13-40.—Determination of double-choker hitch sling capacity.

- Wear or scraping on one third of the original diameter of outside individual wires

- Kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure

- Evidence of heat damage

- End attachments that arc cracked, deformed, or worn

- Hooks that have an obviously abnormal (usually 15 percent from the original specification) throat opening, measured at the narrowest point or twisted more than 10 degrees from the plane of the unbent hook

- Corrosion of the wire rope sling or end attachments

To avoid confusion and to eliminate doubt, you must not downgrade slings to a lower rated capcity. A sling must be removed from service if it cannot safely lift the load capacity for which it is rated. Slings and hooks removed from service must be destroyed by cutting before disposal. This ensures inadvertent use by another unit.

When a leg on a multiple-leg bridle sling is unsafe, you only have to destroy the damaged or unsafe leg(s). Units that have the capability may fabricate replacement legs in the field, provided the wire rope replacement is in compliance with specifications. The NCF has a hydraulic swaging and splicing kit in the battalion Table of Allowance (TOA). The kit, 80092, contains the tools and equipment necessary to fabricate 3/8- through 5/8-inch sizes of wire rope slings. Before use, all fabricated slings must be proof-tested as outlined in the COMSECOND/COMTHIRDNCBINST 11200.11.

Spreader bars, shackles, hooks, and so forth, must also be visually inspected before each usc for obvious damage or deformation.

Check fiber line slings for signs of deterioration, caused by exposure to the weather. See whether any of the fibers have been broken or cut by sharp-edged objects.

Proof Testing Slings

All field fabricated slings terminated by mechanical splices, sockets, and pressed and swaged terminals must be proof-loaded before placing the sling in initial service.

The COMSECOND/COMTHIRDNCBINST 11200.11 has rated capacity charts enclosed for numerous wire rope classifications. You must know the diameter, rope construction, type core, grade, and splice on the wire rope sling before referring to the charts. The charts will give you the vertical-rated capacity for the sling. The test weight for single-leg bridle slings and endless slings is the vertical-rated capacity (V. R. C.) multiplied by two (V.R.C. x 2 = sling test weight).

The test load for multiple-leg bridle slings must be applied to the individual legs and must be two times the vertical-rated capacity of a single-leg sling of the same size, grade, and wire rope construction. When slings and rigging are broken out of the TOA for field use, they must be proof-tested and tagged before being returned to CTR for storage.

Records

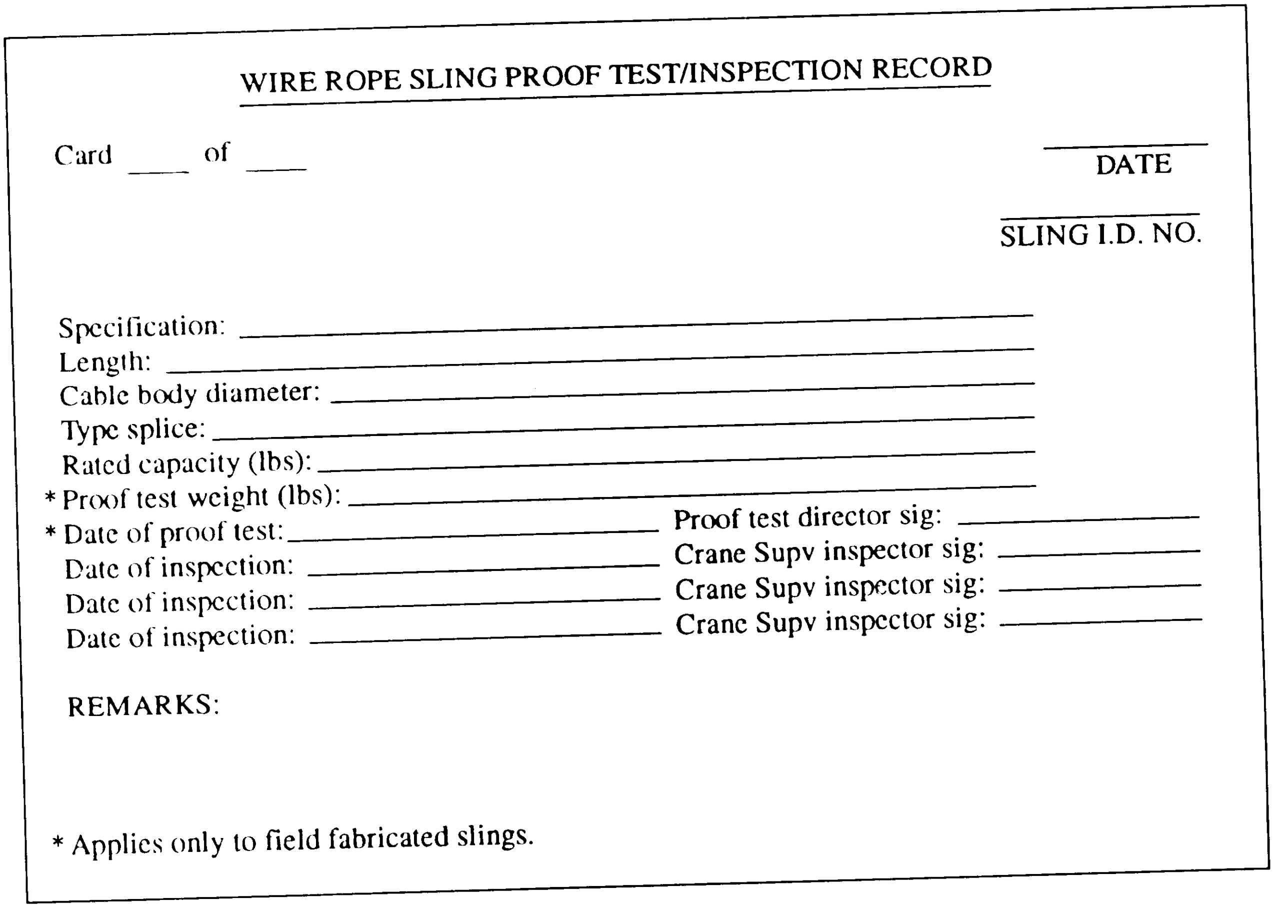
A card file system, containing a record of each sling in the unit's inventory, is established and maintained by the crane crew supervisor. Proof Test/Inspection Sheets (fig. 13-41) are used to document tests made on all items of weight-lifting slings, spreader bars, hooks, shackles, and so forth. These records are permanent and contain the following entries at a minimum:

1. Sling identification number (unit location and two-digit number with Alfa designation for each wire rope component)
2. Sling length
3. Cable body diameter (inches) and specifications
4. Type of splice
5. Rated capacity
6. Proof test weight
7. Date of proof test
8. Signature of proof test director

All the slings must have a permanently affixed, near the sling eye, durable identification tag containing the following information:

1. Rated capacity (in tons) (vert. SWL)
2. Rated capacity (in tons) (45-degree SWL)
3. Identification number

Spreader bars, shackles, and hooks must have the rated capacities and SWL permanent]y stenciled or stamped on them. OSHA identification tugs can be acquired at no cost from COMTHIRDNCB DET, Port Hueneme, California, or COMSECONDNCB DET, GulfPort, Mississippi. Metal dog tags are authorized providing the required information is stamped onto the tags.



WIRE ROPE SLING PROOF TEST/INSPECTION RECORD

Card ____ of ____

______ DATE

______ SLING I.D. NO.

Specification: ______

Length: ______

Cable body diameter: ______

Type splice: ______

Rated capacity (lbs): ______

* Proof test weight (lbs): ______

* Date of proof test: ______ Proof test director sig: ______

Date of inspection: ______ Crane Supv inspector sig: ______

Date of inspection: ______ Crane Supv inspector sig: ______

Date of inspection: ______ Crane Supv inspector sig: ______

REMARKS:

* Applies only to field fabricated slings.

Figure 13-41.—Proof Test/Inspection Sheet.

Storage

Wire rope slings and associated hardware must be stored either in coils or on reels, hung in the rigging loft, or laid on racks indoors to protect them from corrosive weather and other types of damage, such as kinking or being backed over. Slings are not to be left on the crane at the end of the workday.

MECHANICAL, ADVANTAGE

The push or pull a human can exert depends on the weight and strength of that individual. To move any load heavier than the amount you can physically move, a mechanical advantage must be used to multiply your power. The most commonly used mechanical devices are block and tackle, chain hoist, and winches.

BLOCK AND TACKLE

A **block** (fig. 13-42) consists of one or more sheaves fitted in a wood or metal frame supported by a shackle

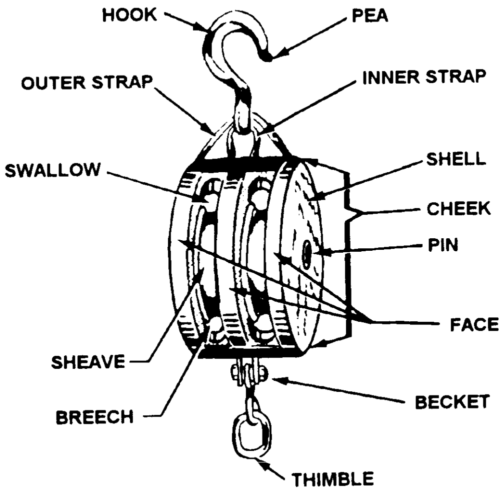


Figure 13-42.—Parts of a fiber line block.

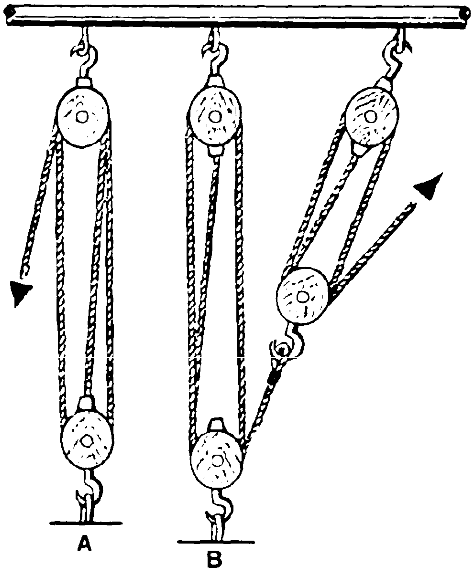


Figure 13-43.—A. Simple tackle; B. Compound tackle.

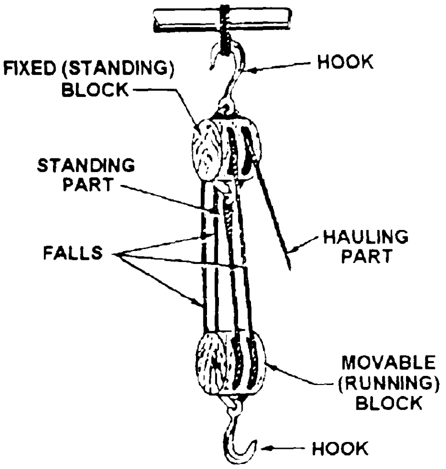


Figure 13-44.—Parts of a tackle.

inserted in the strap of the block. A **tackle** (fig. 13-43) is an assembly of blocks and lines used to gain a mechanical advantage in lifting and pulling.

In a tackle assembly, the line is reeved over the sheaves of blocks. The two types of tackle systems are **simple** and **compound.** A simple tackle system is an assembly of blocks in which a single line is used (fig. 13-43, view A). A compound tackle system is an assembly of blocks in which more than one line is used (fig. 13-43, view B).

Various terms used with a tackle, as shown in figure 13-44, are as follows:

- The **fall** is either a wire rope or a fiber line reeved through a pair of blocks to form a tackle.
- The **hauling part** of the fall leads from the block upon which the power is exerted. The **standing part** is the end which is attached to a becket.
- The **movable** (or **running) block** of a tackle is the block attached to a fixed objector support. When a tackle is being used, the movable block moves and the fixed block remains stationary.
- **"Two blocked"** means that both blocks of a tackle are as close together as they will go. You may also hear this term called **block and block.**
- To **"overhaul"** means to lengthen a tackle by pulling the two blocks apart.
- To **"round in"** means to bring the blocks of a tackle toward each other, usually without a load on the tackle (opposite of overhaul).

The block(s) in a tackle assembly change(s) the direction of pull, provide(s) mechanical advantage, or both. The name and location of the key parts of a fiber line block, as shown in figure 13-42, are as follows:

- The **frame** (or **shell),** made of wood or metal, houses the sheaves.
- The **sheave** is around, grooved wheel over which the line runs. Usually the blocks will have one, two, three, or four sheaves. Some blocks will have up to eleven sheaves.
- The **cheeks** are the solid sides of the frame or shell.
- The **pin** is a metal axle that the sheave turns on. It runs from cheek to cheek through the middle of the sheave.
- The **becket** is a metal loop, formed at one or both ends of a block; the standing part of the line is fastened to the becket.
- The **straps** hold the block together and support the pin on which the sheaves rotate.
- The **shallow** is the opening in the block through which the line passes.
- The **breech** is the part of the block opposite the swallow.

Blocks are constructed for use with fiber line or wire rope. Wire rope blocks are heavily constructed and have large sheaves with deep grooves. Fiber line blocks are generally not as heavily constructed as wire rope blocks and have smaller sheaves with shallow, wide grooves. A large sheave is needed with wire rope to prevent sharp bending. Because fiber line is more flexible and pliable, it does not require sheaves as large as that required for wire rope of the same size.

Blocks, fitted with one, two, three, or four sheaves, are often referred to as single, double, triple, and quadruple blocks. Blocks are fitted with a number of attachments, such as hooks, shackles, eyes, and rings. Figure 13-45 shows two metal framed, heavy-duty blocks. Block A is designed for manila line, and block B is for wire rope.

Block to Line Ratio

The size of a fiber line block is designated by the length in inches of the shell or cheek. The size of a standard wire rope block is controlled by the diameter of the rope. With nonstandard and special-purpose wire rope blocks, the size is found by measuring the diameter of one of its sheaves in inches.

Use care in selecting the proper size line or wire for the block to be used. If a fiber line is reeved onto a tackle whose sheaves are below a certain minimum diameter, the line becomes distorted that causes unnecessary wear. A wire rope too large for a sheave tends to be pinched that damages the sheave. Also, the wire will be damaged because of too short a radius of bend. A wire rope too small for a sheave lacks the necessary bearing surface, puts the strain on only a few strands, and shortens the life of the wire.

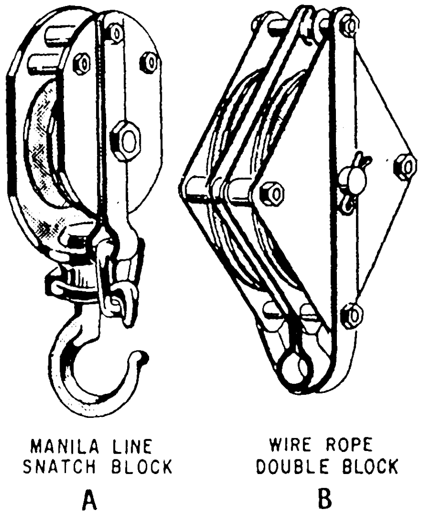


Figure 13-45.-Heavy-duty blocks.

With fiber line, the length of the block used should be about three times the circumference of the line. However, an inch or so either way does not matter too much; for example, a 3-inch line maybe reeved onto an 8-inch block with no ill effects. As a rule, you are more likely to know the block size than the sheave diameter. However, the sheave diameter should be about twice the size of the circumference of the line used.

Wire rope manufacturers issue tables that give the proper sheave diameters used with the various types and sizes of wire rope they manufacture. In the absence of these, a rough rule of thumb is that the sheave diameter should be about 20 times the diameter of the wire. Remember with wire rope, it is the **diameter,** rather than circumference, and this rule refers to the diameter of the sheave, rather than to the size of the block, as with line.

Block Safety

Safety items when using block and tackle are as follows:

- Always stress **safety** when hoisting and moving heavy objects around personnel with block and tackle.

- Always check the condition of blocks and sheaves before using them on a job to make sure they are in safe working order. See that the blocks are properly greased. Also, make sure that the line and sheave are the right size for the job.

- Remember that sheaves or drums which have become worn, chipped, or corrugated must not be used, because they will injure the line. Always find out whether you have enough mechanical advantage in the amount of blocks to make the load as easy to handle as possible.

- You must NOT use wire rope in sheaves and blocks designed for fiber line. They are not strong enough for that type of service, and the wire rope will not properly fit the sheaves grooves. Likewise, sheaves and blocks built for wire rope should NEVER be used for fiber line.

CHAIN HOISTS

Chain hoists provide a convenient and efficient method for hoisting by hand under particular circumstances. The chief advantages of chain hoists are that the load can remain stationary without requiring attention and that the hoist can be operated by one man to raise loads weighing several tons. The slow lifting travel of a chain hoist permits small movements, accurate adjustment of height, and gentle handling of loads. A ratchet handle pull hoist is used for short, horizontal pulls on heavy objects. Chain hoists differ widely in their mechanical advantage, depending upon their rated capacity.

Three general types of chain hoists for vertical operation are the spur gear hoist, the differential chain hoist, and the screw gear hoist.

The spur gear hoist (fig. 13-46, view A) is the most satisfactory for ordinary operations. This type of hoist is about 85 percent efficient. The differential chain hoist (fig. 13-46, view B) is only about 35 percent efficient and is satisfactory for occasional use and light loads. The screw gear hoist is about 50 percent efficient and is satisfactory where less frequent use of the hoist is required.

Chain hoists arc usually stamped with their load capacities on the shell of the upper block. Chain hoists are constructed with their lower hook as the weakest part of the assembly. This is done as a precaution, so the lower hook will be overloaded before the chain hoist is overloaded. The lower hook will start to spread under load, indicating the approaching overload limit. Under ordinary circumstances the pull, exerted on a chain hoist by one or two people, will not overload the hoist.

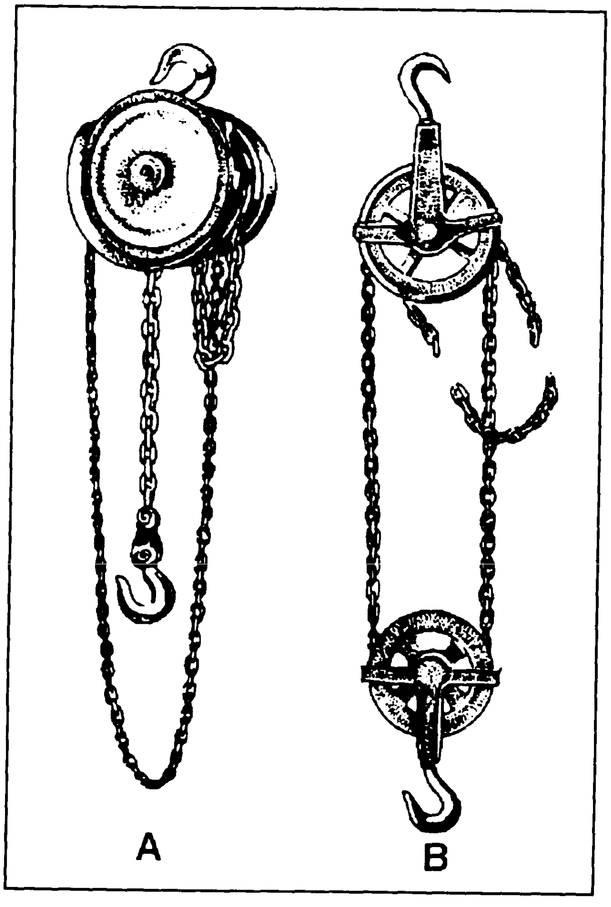


Figure 13-46.-A. Spur gear chain hoist; B. Differential chain hoist.

Chain hoists should be inspected before each use. Any evidence of spreading of the hook or excessive wear is sufficient cause to require replacement of the hook. If the links of the chain are distorted, it indicates that the chain hoist has been heavily overloaded and probably unsafe for further use. Under such circumstances the chain hoist should be condemned. Before using any permanently mounted chain hoists, you should ensure that the annual certification is current.

WINCHES

Vehicular-mounted winches and engine-driven winches are sometimes used in conjunction with tackles for hoisting. When placing a power winch to operate hoisting equipment, you must consider two points. First, you must consider the angle with the ground that the hoisting line makes at the drum of the hoist. This angle is sometimes referred to as **ground angle,** as shown in figure 13-47. The second point to consider is the **fleet angle** of the hoisting line winding on the drum, as shown

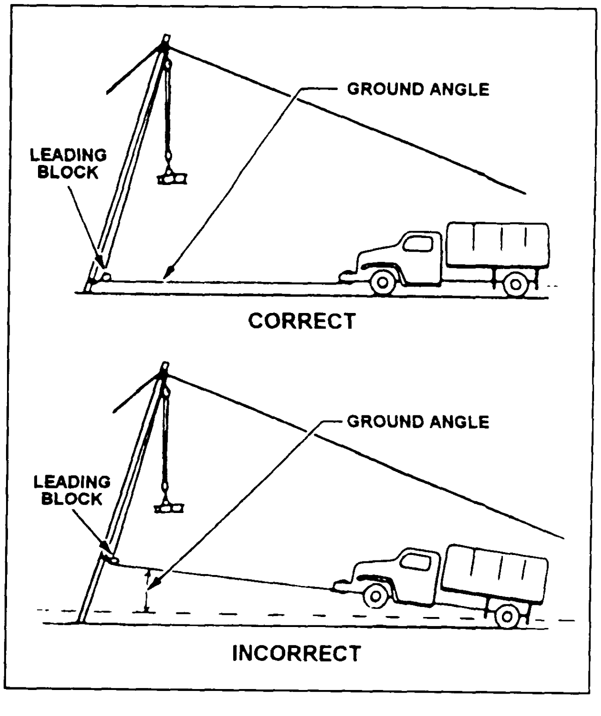


Figure 13-47.—Vehicle winch used for hoisting.

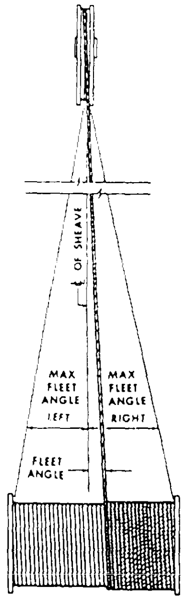


Figure 13-48.—Fleet angle of winch.

in figure 13-48. The distance from the drum to the sheave is the controlling factor in the fleet angle.

When you are using vehicle-mounted winches, the vehicle should be placed in a position which permits the operator to watch the load being hoisted. A winch is most effective when the pull is exerted on the bare drum of the winch. When a winch is rated at capacity, the rating applies only as the first layer of cable is wound onto the drum. The winch capacity is reduced as each layer of cable is wound onto the drum because of the change in leverage, resulting from the increased diameter of the drum. The capacity of the winch maybe reduced by as much as 50 percent when the last layer is being wound onto the drum.

Ground Angle

If the hoisting line leaves the drum at an angle upward from the ground, the resulting pull on the winch will tend to lift it off the ground. In this case, a leading block must be placed in the system at some distance from the drum to change the direction of the hoisting line to a horizontal or downward pull. The hoisting line should be overwound or underwound on the drum as may be necessary to avoid a reverse bend.

Fleet Angle

The drum of the winch is placed so that a line from the last block passing through the center of the drum is at right angles to the axis of the drum. The angle between this line and the hoisting line as it winds on the drum is call the fleet angle. As the hoisting line is wound in on the drum, it moves from one flange to the other, so the fleet angle changes during the hoisting process. The fleet angle should not be permitted to exceed 2 degrees and should be kept below this if possible. A 1 1/2-degree maximum angle is satisfactory and will be obtained if the distance from the drum to the first sheave is 40 inches for each inch from the center of the drum flange. The wider the drum of the hoist, the greater the lead distance must be in placing the winch.

RIGGING SAFE OPERATING PROCEDURES

All personnel involved with the use of rigging gear should be thoroughly instructed and trained to comply with the following practices:

1. Wire rope slings must not be used with loads that exceed the rated capacities outlined in enclosure (2) of the COMSECOND/COMTHIRDNCBINST 11200.11. Slings not included in the enclosure must be used only according to the manufacturer's recommendation.

2. Determine the weight of a load before attempting any lift.

3. Select a sling with sufficient capacity rating.

4. Examine all hardware, equipment, tackle, and slings before using them and destroy all defective components.

5. Use the proper hitch.

6. Guide loads with a tag line when practical.

7. When using multiple-leg slings, select the longest sling practical to reduce the stress on the individual sling legs.

8. Attach the sling securely to the load.

9. Pad or protect any sharp corners or edges the sling may come in contact with to prevent chaffing.

10. Keep the slings free of kinks, loops, or twists.

11. Keep hands and fingers from between the sling and the load.

12. To avoid placing shock on the loading slings, you should start the lift slowly.

13. Keep the slings well lubricated to prevent corrosion.

14. Do not pull the slings from under a load when the load is resting on the slings; block the load up to remove the slings.

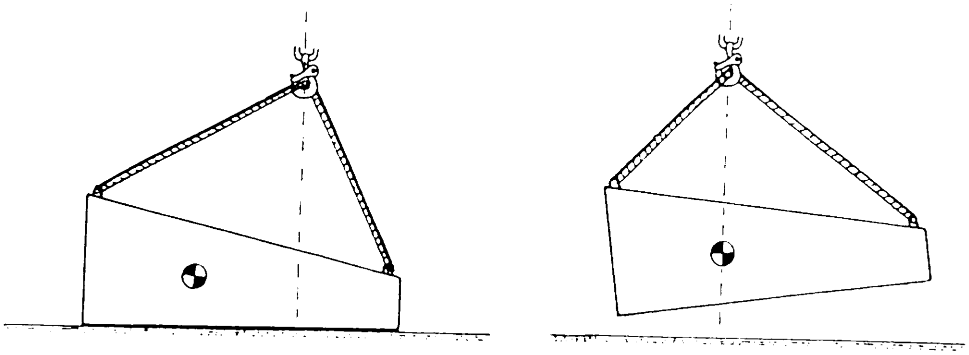


Figure 13-49.—Load shifting when Lifted.

15. Do not shorten a sling by knotting or using wire rope clips.

16. Do not inspect wire rope slings by passing bare hands over the rope. Broken wires, if present, may cause serious injuries. When practical, leather palm gloves should be worn when working with wire rope slings.

17. Center of balance. Stability of the load is important in the rigging process. A stable load is a load in which the center of balance of the load is directly below the hook, as shown in figure 13-49. When a load is suspended, it will always shift to that position below the hook. To rig a stable load, establish the center of balance (C/B). Once you have done this, simply swing the hook over the C/B and select the length of sling needed from the hook to the lifting point of the load.

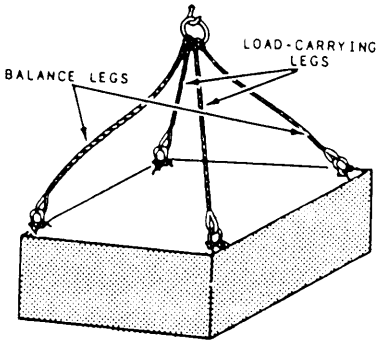


Figure 13-50.—Multi-legged bridle sling lifting a load.

18. When using a multi-legged bridle sling, do not forget it is wrong to assume that a three- or four-leg hitch will safely lift a load equal to the safe load on one leg multiplied by the number of legs. With a four-legged bridle sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two only balance it (fig. 13-50).

NOTE: If all the legs of a multi-legged sling are not required, secure the remaining legs out of the way, as shown in figure 13-51.

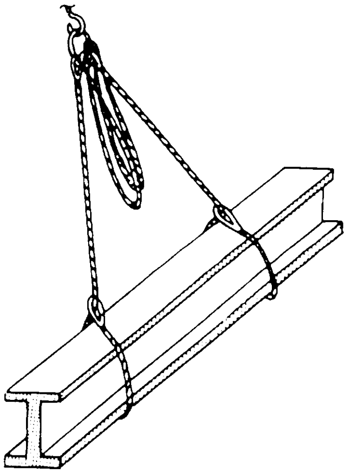


Figure 13-51.—Secure sling legs that are not used.

CHAPTER 14

MISCELLANEOUS EQUIPMENT

Mixing equipment, drilling equipment, compressed air equipment, and miscellaneous construction and maintenance equipment are procured for the Naval Construction Force (NCF) to support specific construction and maintenance operations.

This chapter covers the characteristics and basic principles of operations of mixing equipment, drilling equipment, compressed air equipment, and miscellaneous construction and maintenance equipment. These types of equipment play a vital part in NCF operations; therefore, as an equipment operator, you should become familiar with the capabilities of the equipment and how it can be used to serve the purpose for which it was designed.

CONCRETE TRANSIT MIXER

A concrete transit mix truck, sometimes called a TM, is a traveling concrete mixer (fig. 14-1). The truck carries a mixer and a water tank from which the operator can, at the proper time, introduce the required amount of water into the mix. The operator picks up the dry ingredients at the batch plant along with a chit that tells how much water is to be introduced to the mix. The mixer drum is kept revolving en route and at the jobsite, so the dry ingredients do not segregate.

When a TM is used for mixing concrete, 70 to 100 revolutions of the drum at the rate of rotation, designated by the manufacturer as **mixing speed,** are usually required to produce the specified uniformity. No more than 100 revolutions at mixing speed should be used. All revolutions after 100 should be at the rate of rotation designated by the manufacturer as **agitating speed.** Agitating speed is usually about 2 to 6 revolutions per minute, and mixing speed is generally about 6 to 18 revolutions per minute. Mixing for long periods of time at high speeds, about 1 or more hours, can result in concrete strength loss, temperature rise, excessive loss of entrained air, and accelerated slump loss.

Concrete, mixed in a transit mixer, should be delivered within 1 1/2 hours or before the drum has revolved 300 times after the introduction of water to cement and aggregates or the cement to the aggregates. Mixers and agitators should always be operated within the limits of the volume and speed of rotation designated by the manufacturer.

DISCHARGE CHUTES

The operator must have the proper chutes at the delivery site or on the truck before delivering concrete. Open-trough chutes should be of metal or metal-lined,

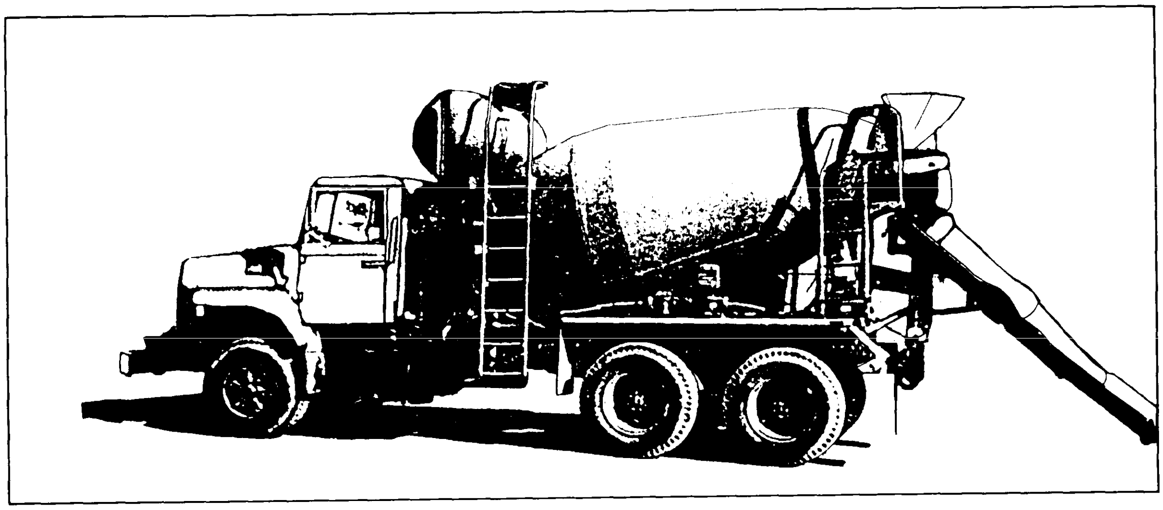


Figure 14-1.—Concrete transit mixer.

preferably round-bottomed, and large enough to guard against overflow (fig. 14-2).

The maximum or minimum slope should be determined by the condition of the concrete as discharged from the chute. Quality control personnel on the jobsite should provide guidance in this area.

When possible, you should install a downpipe on the end of the chute to help keep the concrete from segregating when coming off the end of the chute.

OPERATION

Be sure to read the operator's manual for the type of concrete mixer you are operating. Give special attention to the following:

1. Ensure the chain drip oiler is filled and turned on at the beginning of operation.

2. Check the oil level in the hydrostatic drive unit at the sight glass.

3. Check the water tank and meter valves of the on-board water system for the following: operating condition, clean tank, and all valves are clear.

Cleaning

Give special care to cleaning the transit mixer. At the beginning of each workday, the mixer should be coated with form oil to prevent cement and concrete from sticking to the paint or bare metal. After the load of concrete is discharged from the mixer, the operator should wash off all excess concrete in the mixer drum and blades, the discharge chute opening, and the discharge chute before it has a chance to harden. Spraying 15 to 25 gallons of water into the drum while it is rotating will clean the inside of the drum as well as remove all grout which may have collected in the water nozzle during discharge. A washdown hose is provided on the mixer to clean areas accessible from the outside.

CAUTION

Consult your supervisor about any environmental regulations that require

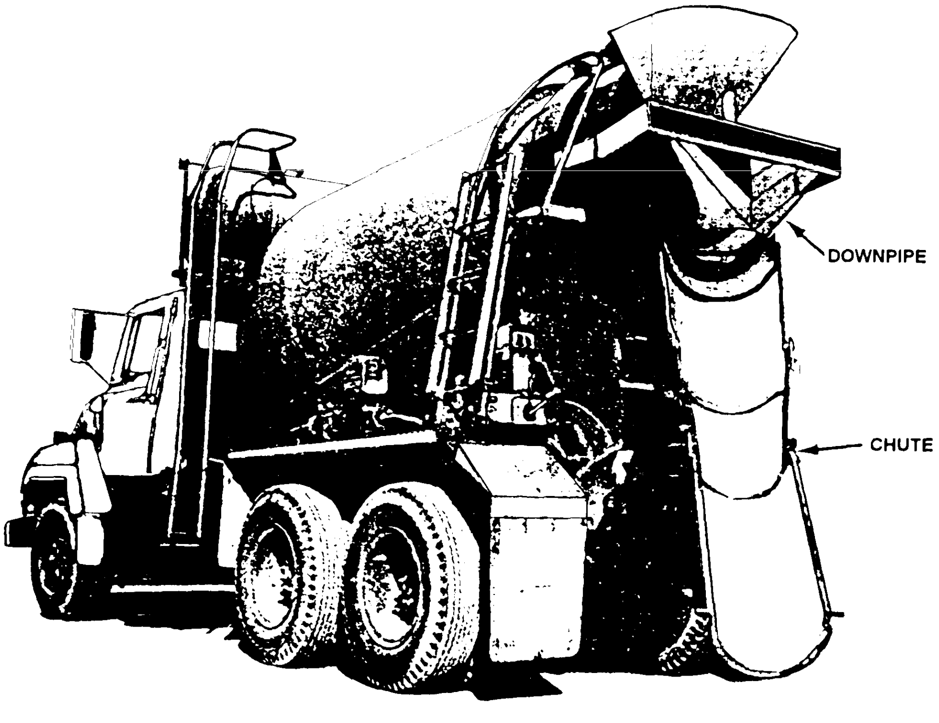


Figure 14-2.-Chutes used for discharging concrete.

collection or diversion of wash water from mixer equipment.

At the plant, flush a minimum of 150 to 250 gallons of water, depending on the size of the mixer, into the drum. With the flushed water in the drum, rotate the drum in the mixing direction for a few minutes, then discharge the flushed water at the maximum drum rpm. Complete the cleaning of the mixer, particularly around the discharge end.

Never pound the bottom of the drum to loosen materials, since this procedure may cause dents and bumps in which concrete and cement can stick. During cold weather, the water tank, pump, and lines must be drained to prevent possible damage from freezing.

The mixing blades inside the drum must be kept clean and free of built-up concrete. If not cleaned properly, the blades in the drum will wear down and this can result in improper mixing. If this occurs, the blades should be either changed or built up by using hardfacing procedures.

If a minor repair is required on a loaded transit mixer, take the TM to the shop for a quick fix. If the downtime is going to be for more than an hour, mix in 5 pounds of sugar or concrete retarder to keep the concrete from setting up inside the truck.

NOTE: A small amount of sugar (5 pounds) acts as a retarder; however, a large amount will act as an accelerator.

If a quick fix is not possible, the concrete must be removed as quickly as possible. Either check for a hydraulic adapter, which can be hooked up to another TM to operate the drum to discharge the concrete, or remove the access hatch from the drum, roll the drum until the access hatch is facing down, and washout the concrete mix, if possible.

Safety

Like most construction equipment, transit mixers, when not operated safely, can injure or kill personnel and damage property. As a TM operator, keep in mind the following guidelines:

- Transit mixers have a high center of gravity. Their stability is further decreased by the weight of the load. Use extreme caution when traveling over uneven terrain.

- Always use caution and a signalman when backing on a jobsite.

- Remember to secure the discharge chute properly with the chute locked to the right side of the truck for travel.

- Make sure the mixer is stopped before making adjustments.

- Observe environmental regulations concerning disposal of waste and wash water from mixers.

- Avoid prolonged skin contact with concrete or cement.

MOBILE CONCRETE MIXER PLANT

The mobile concrete mixer plant, sometimes called a **crete mobile,** is a combination material transporter and mobile concrete mixing plant (fig. 14-3). In the NCF, the unit is mounted on a trailer that carries sufficient unmixed materials, such as cement, sand, coarse aggregates, water, and any chemicals required, for special mix specifications to the jobsite.

OPERATION

The trailer-mounted crete mobile carries the cement, sand, and coarse aggregates in divided bins, mounted on the unit. The cement is carried in a separate bin, located across the rear of the unit, and the sand and aggregate are carried on each side of the unit. Water is carried in a single tank, mounted in front of the aggregate bins, and is pumped to the mix auger.

Sand and aggregates are proportioned accurately by weight or volume and dropped simultaneously with a mixture of cement from the material feed system into the charging end of the mix auger/conveyor at the rear of the unit. At this point, a predetermined amount of water enters the mix auger. This action of the combined auger and paddle homogenizer mixes the ingredients and water rapidly, thoroughly, and continuously to produce a continuous flow of uniformed quality concrete.

The mixing action is a continuous process that can proceed until the aggregate bins are empty. On the other hand, mixing and delivery may be stopped at any time and then started again at the will of the operator. This permits production to be balanced to the demands of the placing and finishing crews and other job requirements.

NOTE: When cleaning the crete mobile, you must cycle the auger to remove all sand, aggregate, and cement. Excess material in the bin and auger will harden and freeze the components.

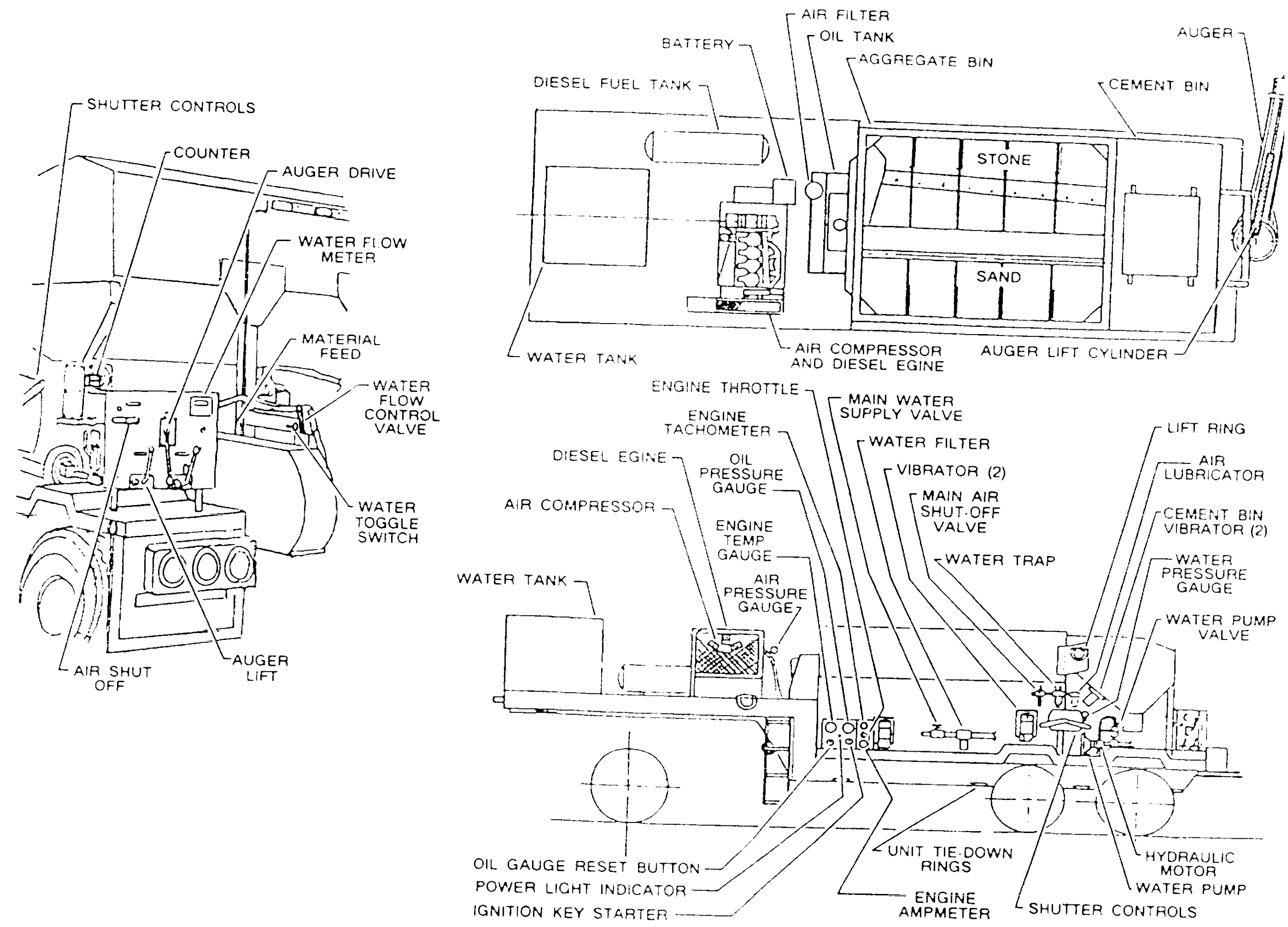

SHUTTER CONTROLS
COUNTER
AUGER DRIVE
WATER FLOW METER
MATERIAL FEED
WATER FLOW CONTROL VALVE
WATER TOGGLE SWITCH
AUGER LIFT
AIR SHUT OFF
AIR FILTER
BATTERY
OIL TANK
AGGREGATE BIN
AUGER
DIESEL FUEL TANK
CEMENT BIN
STONE
SAND
WATER TANK
AIR COMPRESSOR AND DIESEL EGINE
AUGER LIFT CYLINDER
ENGINE THROTTLE
MAIN WATER SUPPLY VALVE
ENGINE TACHOMETER
WATER FILTER
LIFT RING
DIESEL EGINE
OIL PRESSURE GAUGE
VIBRATOR (2)
AIR LUBRICATOR
MAIN AIR SHUT-OFF VALVE
AIR COMPRESSOR
ENGINE TEMP GAUGE
CEMENT BIN VIBRATOR (2)
WATER TRAP
WATER PRESSURE GAUGE
WATER TANK
AIR PRESSURE GAUGE
WATER PUMP VALVE
OIL GAUGE RESET BUTTON
POWER LIGHT INDICATOR
IGNITION KEY STARTER
UNIT TIE-DOWN RINGS
ENGINE AMPMETER
HYDRAULIC MOTOR
WATER PUMP
SHUTTER CONTROLS

Figure 14-3.—Mobile concrete mixer plant.

SAFETY

Operators, assigned to the crete mobile, must read thoroughly and understand the technical manual before operating the plant. A few safety precautions when operating the crete mobile areas follows:

- Follow all preventive maintenance procedures.
- Do NOT allow any foreign matter in the cement bin.
- Do NOT allow particles larger than 1 1/2 inches in the aggregate bin.
- Do NOT allow the waterlines and flowmeters to freeze with water in them.
- Do NOT run the water pump dry.
- Do NOT continue to operate the machine if the hydraulic oil temperature exceeds 190°F.
- Wash out the auger within 20 minutes of the last use.
- Never attempt to repair the machine while in operation (always turn the power source off).
- Keep your entire body clear from all moving parts.
- Never attempt to walk on top of the aggregate bin to cross from the cement bin to the water tank (use the ladder).
- Never walk or stand under the auger.
- Never climb inside the aggregate bin (use a small pole to dislodge any aggregate that has bridged).
- Never enter the cement bin while in operation (there are moving parts inside the bin).

EARTH AUGERS

Augers are rotary drills with a helix or screw thread on drill rods, called augers or flights. Augers can be truck- or skid-mounted or hand-held. Figure 14-4 shows a 5-ton tactical auger truck commonly used in the

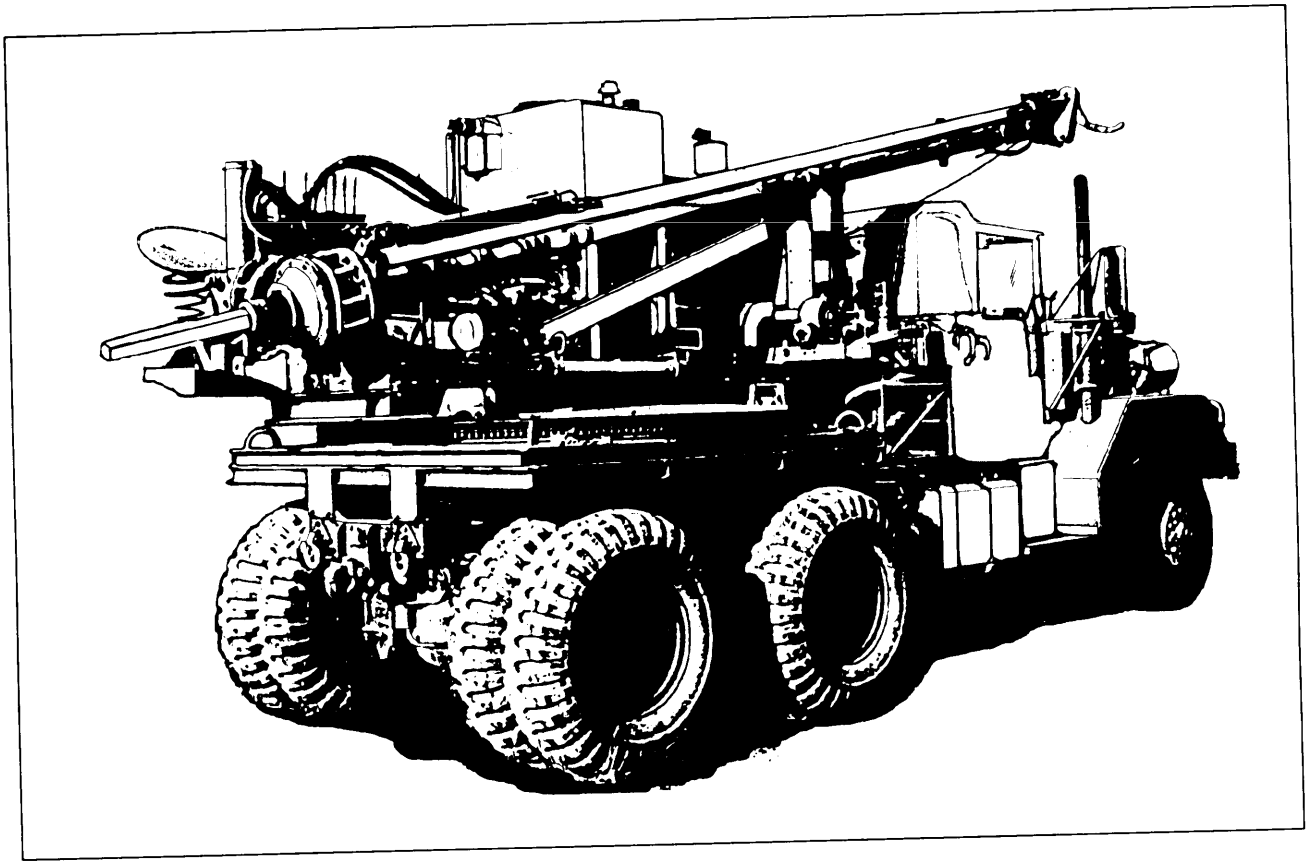


Figure 14-4.-Auger truck.

NCF. Notice in figure 14-4 that the drill boom lays down and that extra auger heads are stored in the unit. This truck can also set or pull poles.

OPERATIONS

Operating procedures may vary among makes and models of earth augers; therefore, be sure to consult the manufacturer's manual for the specific earth auger you are using.

Auger operational techniques under ordinary circumstances are described below. Figure 14-5 shows the auger controls and how the auger is positioned using these controls.

Leveling

The **leveling valve lever** allows for tilting of the auger shaft to the right or left (fig. 14-5, view A). Use the **leveling spirit level** to plumb the auger shaft. Use support jacks when operating the auger in hardpan or rocky soil to keep the auger from bouncing.

NOTE: Do not depend on the accuracy of the leveling bubble. Use a small builders level to level the auger shaft and machine.

Raising and Lowering

The **elevating valve lever** is used to raise or lower the auger shaft for transposing (fig. 14-5, view B).

Drilling and Retracting

To drill with the auger, engage the auger **clutch lever,** increase the engine speed by pulling back on the **throttle lever,** and push forward on the **feed valve lever** to lower the auger into the ground (fig. 14-5, view C).

NOTE: Do NOT overspeed the auger. Run the engine at a lower speed until you know the texture of the material with which you are working.

When the auger is deep enough into the ground and is covered with the cuttings, disengage the auger **clutch lever** and pull back on the **feed valve lever** to raise the auger from the hole. After the auger has cleared the hole, engage the auger **clutch lever** to rotate the auger

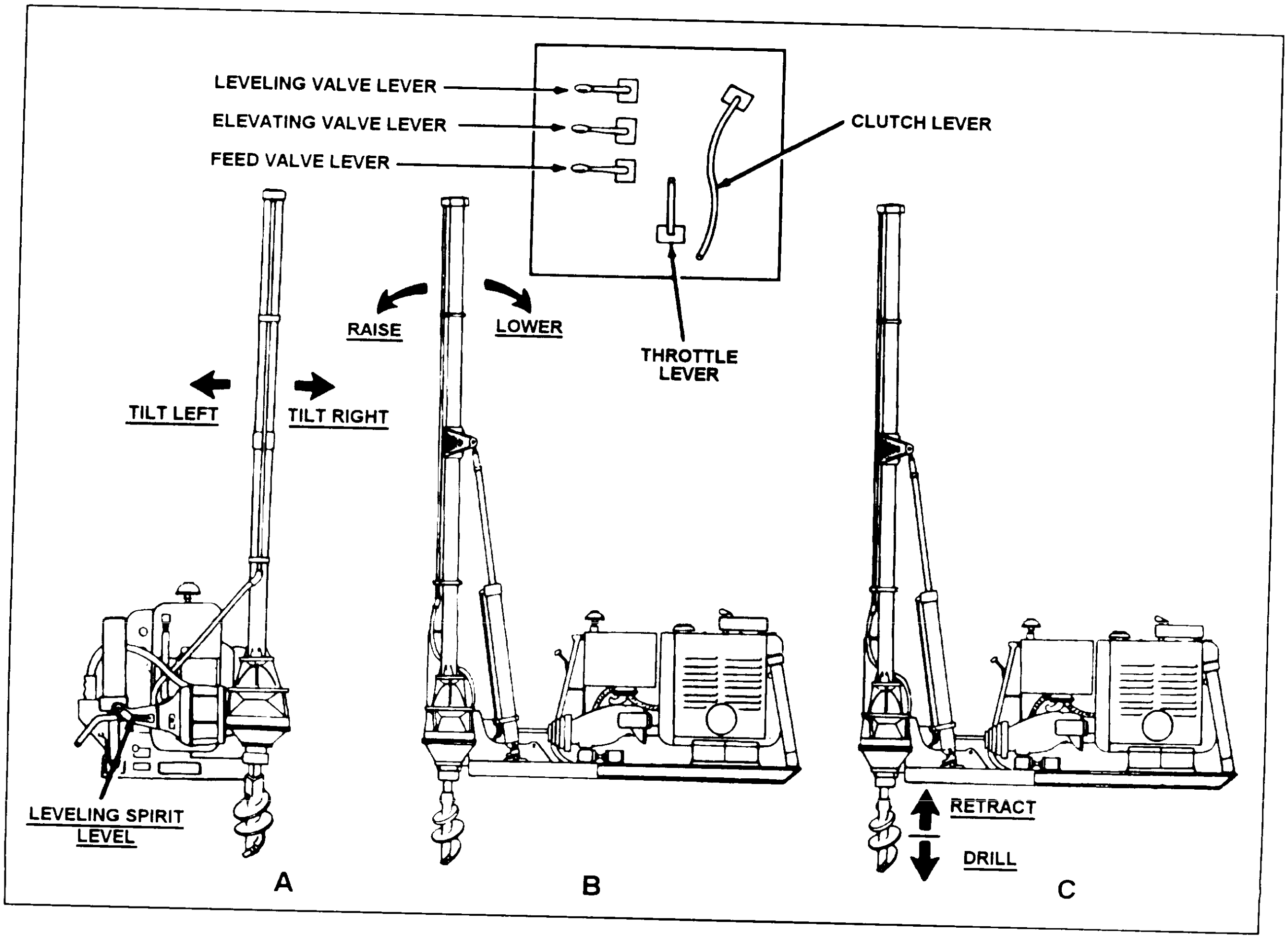

LEVELING VALVE LEVER
ELEVATING VALVE LEVER
FEED VALVE LEVER
CLUTCH LEVER
THROTTLE LEVER
RAISE
LOWER
TILT LEFT
TILT RIGHT
LEVELING SPIRIT LEVEL
RETRACT
DRILL
A
B
C

Figure 14-5.—Using auger controls for positioning of auger.

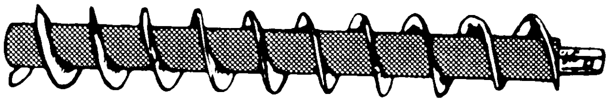


Figure 14-6.-Continuous-flight auger.

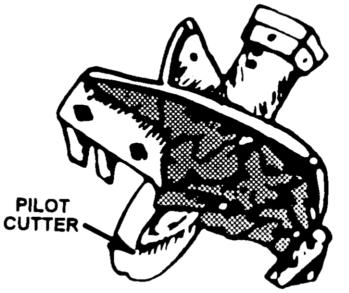

PILOT CUTTER

Figure 14-7.-Single-flight auger.

and to clear the bit of cuttings. Remember, as the auger is raised, push the hand throttle forward to lower the engine speed. Repeat these procedures until the hole being drilled reaches the desired depth.

AUGERS

Earth augers may use **continuous-flight augers** (fig. 14-6) or **single-flight augers** (fig. 14-7).

The auger head is attached to the drill shank by a square-drive pin connector. Continuous-flight augers usually come in sizes from 5 to 12 inches in diameter and various lengths. A 5-inch auger can drill about 100 feet in suitable material; a 10-inch auger is limited to about 40 feet.

Single-flight augers, lifted after every 8 to 10 inches of penetration to clear the cuttings, measure from 14 to 36 inches in diameter. Single-flight augers are limited to depths of about 15 feet.

Various sizes of auger heads (fig. 14-8) are available for different job specifications. Most of them feature an advance center or pilot cutter that helps keep the drill hole alignment straight and makes the cutting easier for the larger auger head. As shown in figure 14-9, the head should be slightly larger than the auger flights, so it will not bind or stick in the hole.

These heads can also be made of different materials to meet unlike soil conditions. Cutting edges and teeth are usually steel-hardened by various means, such as tungsten carbide. Worn or broken teeth may be built up by hardfacing. These teeth are sometimes called fingers and are generally detachable or reversible.

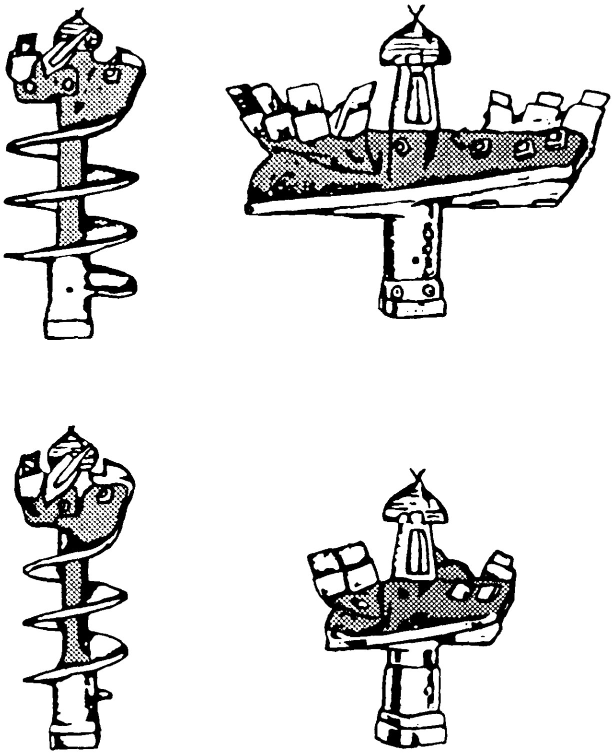


Figure 14-8.—Auger boring heads.

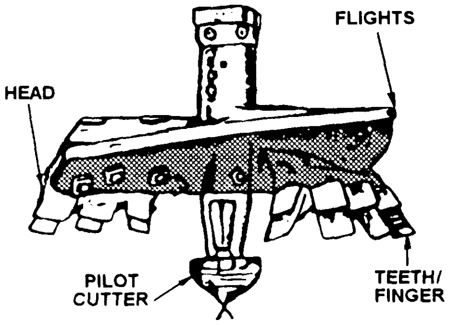


Figure 14-9.—Auger boring head nomenclature.

DRILLING

Drilling resistance or control of the rate of feed prevents the threads from penetrating in proportion to their turning speed. Material, cut by the bit, is gripped by the threads and forced out of the hole by the screw conveyor action. The flights are made in sections proportional to the feed length of the drill unit and are connected to each other by bolting or pinning.

SAFETY

A few safety precautions when operating an auger are as follows:

- Obtain a digging permit before drilling or boring.
- Have all underground utilities and obstructions marked and identified.
- When traveling with the auger truck, make sure all attachments are secured properly.
- Always sound the horn and use a backing guide when backing the auger.
- Do NOT travel with an auger bit attached to the drill shank. This practice can result in destruction of the drill shank inner seals.
- Do NOT allow personnel to stand near the auger when boring holes.
- Do NOT allow personnel to stand near the auger when swinging or moving the auger boom.
- Do NOT exceed the capacity of the auger when pulling or setting poles.
- Do NOT try to remove any objects from the auger when the auger is running.
- When boring into material of unknown consistency, run the unit at low speed.
- Always protect personnel from open holes by placing caution tape and covers around and over the holes, and illuminate the area with lighting at night.

AIR COMPRESSORS

A compressor is a machine that compresses air from an initial intake pressure to a higher exhaust pressure through a reduction in volume. A compressor consists of a power source, a compressor unit, and accessory equipment. A gasoline or diesel engine provides power to operate the compressor. Most compressors, used in the NCF, are governed by a pressure control system, adjusted to compress air to a maximum pressure of 100 pounds per square inch (psi). Compressor units are available in reciprocating, rotary, or screw design.

Compressors are classified as either **single-stage** or **multistage.** A single-stage compressor has one compressing element that compresses the air from the initial intake pressure to the final discharge pressure in one step. The multistage compressor has more than one compressing element. The first stage compresses the air to an intermediate pressure, then through one or more additional stages to final discharge pressure. The multistage system is more efficient than the single-stage system, because the air cooling that occurs between stages reduces buildup of pressure due to a temperature rise.

All military construction compressors are governed by a pressure control system. In a **reciprocating compressor,** this control system causes the engine to idle and the suction valve to remain open when the pressure reaches a set maximum. When the air pressure drops below a set minimum, the pressure control system causes the engine to increase speed and the suction valve to close, starting the compression cycle again. The **rotary compressor** output is governed by varying the engine speed. The engine operates automatically at the speed needed to compress enough air to supply the demand at a fairly constant pressure. When the engine has slowed to idle because of low demand, a valve throttles the amount of free air that may enter the compressor.

The **screw compressor** output is controlled automatically and provides a smooth, uninterrupted capacity from full load to no load in response to the demand for air. This capacity is achieved by a floating speed engine control and a variable inlet compressor.

COMPRESSOR CAPACITY

The capacity of an air compressor is determined by the amount of free air (at sea level) that it can compress to a specified pressure, usually 100 psi per minute, under the conditions of 68°F and a relative humidity of 38 percent. This capacity is expressed in **cubic feet per minute** (cfm) and is usually included in the nomenclature of the compressor.

The number of pneumatic tools that can be operated at one time from an air compressor depends on the air requirements of each tool; for example, a 55-pound class rock drill requires 95 cfm of air at 80 psi. A 210-cfm compressor can supply air to operate two of the drills, because their combined requirements is 190 cfm. However, if a third such drill is added to the compressor, the combined demand is 285 cfm, and this condition overloads the compressor and the tools and results in serious wear.

NOTE: When the pressure and volume of air to a pneumatic tool drops 10 percent below the designed minimum, the tool efficiency is reduced 41 percent.

Compressor Location

Install the compressor unit so it is as close to level as possible. Compressor design permits a 15-degree lengthwise and a 15-degree sidewise limit on out-of-level operation. The engine, not the compressor, is the limiting factor. When the unit is to be operated out of level, you should be sure to do the following:

1. Keep the engine crankcase oil level on the full mark with the unit level.

2. Ensure the compressor oil gauge shows full with the unit level.

Compressed Air System

A compressed air system consists of one or more compressors, each with the necessary power source, regulation, intake air filter, aftercooler, air receiver, connecting piping, and a distribution system to carry the air to points of use. The object of installing a compressed air system is to provide enough air at the work area at pressures adequate for efficient operation of pneumatic tools.

Many construction jobs require more cfm than one compressor can produce. Also, terrain conditions often create problems of distance from the compressor to the operating tool. Since the air line hose causes a loss of pressure (friction loss) at distances farther than 200 feet, a system has been devised for efficient transmission of compressed air over longer distances. This system is air manifolding (fig. 14- 10).

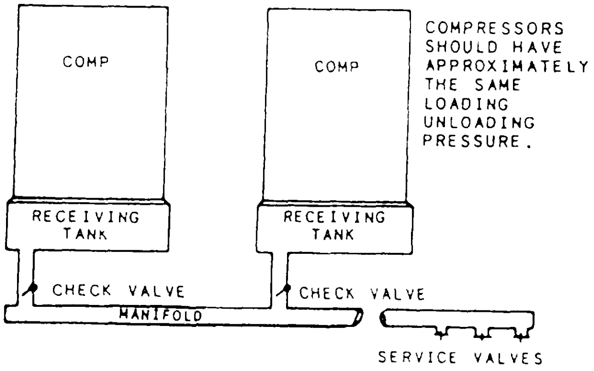


Figure 14-10.—Methods of manifolding compressors.

An air manifold is a large-diameter pipe that transports compressed air from one or more compressors over considerable distances without friction line loss. In construction work, air manifolds are usually constructed of 6-inch-diameter pipe with check valves. A pipe of this size can carry 1,200 cfm of air (output from two 600-cfm air compressors) at 100 psi with less than 0.035-pound pressure loss per 100 linear feet. One or more compressors pump air into the manifold and then "pressurize" it at 100 psi. Air may then be used at any point along the manifold by installing outlet valves and connecting airlines to pneumatic tools.

CAUTION

> Different types of compressors should not be used on the same manifold. The difference in pressure control systems of a rotary, a reciprocating, and a screw compressor could cause one compressor to be overloaded, while the other is idled.

Any drop in pressure between the compressor and the point of use is a permanent loss. Because of this, the air distribution system is an important element of the compressed air system. When planning the air system, you should observe the following steps:

- Pipe size should be large enough to ensure the pressure drop between the compressor and the point of use does not exceed 10 percent.
- Extremely long distribution lines should have air receivers near the far ends or at points of occasional heavy use. Many peak demands for compressed air are only for an instant, and storage capacity near such points prevents an excessive drop in line pressure.
- Each header or main should be provided with outlets as close as possible to the point of use to permit shorter hose lengths and to avoid large pressure drops through the hose. Outlets should always be located at the top of the pipeline to prevent carry-over of condensed moisture to the tool. Condensate drains should be positioned correctly along the header or main line.

SAFETY

General safety precautions for air compressors are as follows:

- Be sure the intake air is cool and free from flammable gases or vapors.
- Do NOT permit flammable materials to touch the air discharge pipe.
- Never operate a compressor that has faulty gauges.
- Never kink a hose to stop the air flow, and keep the hose clamps on tight.
- Before starting an air compressor, check the safety valves, pressure valves, and regulators to see that they are working properly.
- Do NOT leave the compressor after starting it unless you are sure the control, unloading, and governing devices are working properly.
- Do NOT run an air compressor faster than the speed recommended by the manufacture.
- Use only the grade and amount of oil recommended by the manufacturer. Use only high flash point oils to lubricate the air cylinders of air compressors.
- Keep compressors, tanks, and accompanying piping clean to guard against oil vapor explosion. Clean intake air filters regularly.
- Use only soapy water or a suitable nontoxic, nonflammable solution for cleaning compressor intake filters, cylinders, or air passages. Never use benzene, kerosene, or other light oils to clean these parts. These oils vaporize easily and form a mixture that is highly explosive under compression.
- Secure the engine before adjusting and repairing an air compressor.
- Before working on or removing any part of a compressor, make certain that the compressor is secured and cannot be started automatically or accidentally and that the air pressure in the compressor is relieved completely. Also, ensure that all valves between the compressor and receivers are closed.
- Be careful with compressed air. At close range, it can put out eyes, burst eardrums, and cause serious skin burns. Always wear impact goggles or safety glasses and dual-hearing protection when using compressed air. NEVER use compressed air to blow dust off clothing, skin, or hair.
- When transporting a compressor or any other towed unit, ensure the pulling unit meets specifications. This includes drawbar horsepower and height of towing pintle (not too high or low because it can damage the

towing tongue). Ensure all electrical hookups fit and are the right length.

- When parking, ensure the parking brake is applied and wheels are chocked.

- Safety chains must be of proper size and length and secured properly (fig. 14- 11).

PNEUMATIC TOOLS

Pneumatic tools can be used with any type or size compressor as long as the psi and cfm requirements for the tool are met. In the NCF, pneumatic tools are normally stored and checked out from the central toolroom along with the air supply hose.

When checking out a tool, you should determine if the tool needs an in-line oiler. If an in-line oiler (fig. 14- 12) is needed to provide lubrication to the tool, follow the tool manufacturer's recommendation for the correct lubrication.

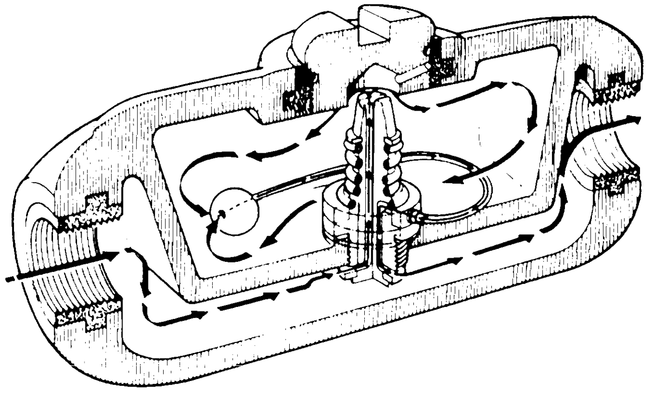


Figure 14-12.—In-line oiler.

PAVEMENT BREAKER/ JACKHAMMER

The pavement breaker resembles a portable rotary rock drill/jackhammer. The pavement breaker consist of a piston that is moving in a chamber under air pressure and weighs between 30 to 90 pounds. The major working parts of a pavement breaker are shown in figure 14-13. Notice no rotational mechanism is provided and no variation in speed is possible. This is the major difference between the pavement breaker and rotary rock drill/jackhammer.

Pavement breaker attachments (fig. 14-14) are the moil point, the chisel point, the asphalt cutter, and the clay spade.

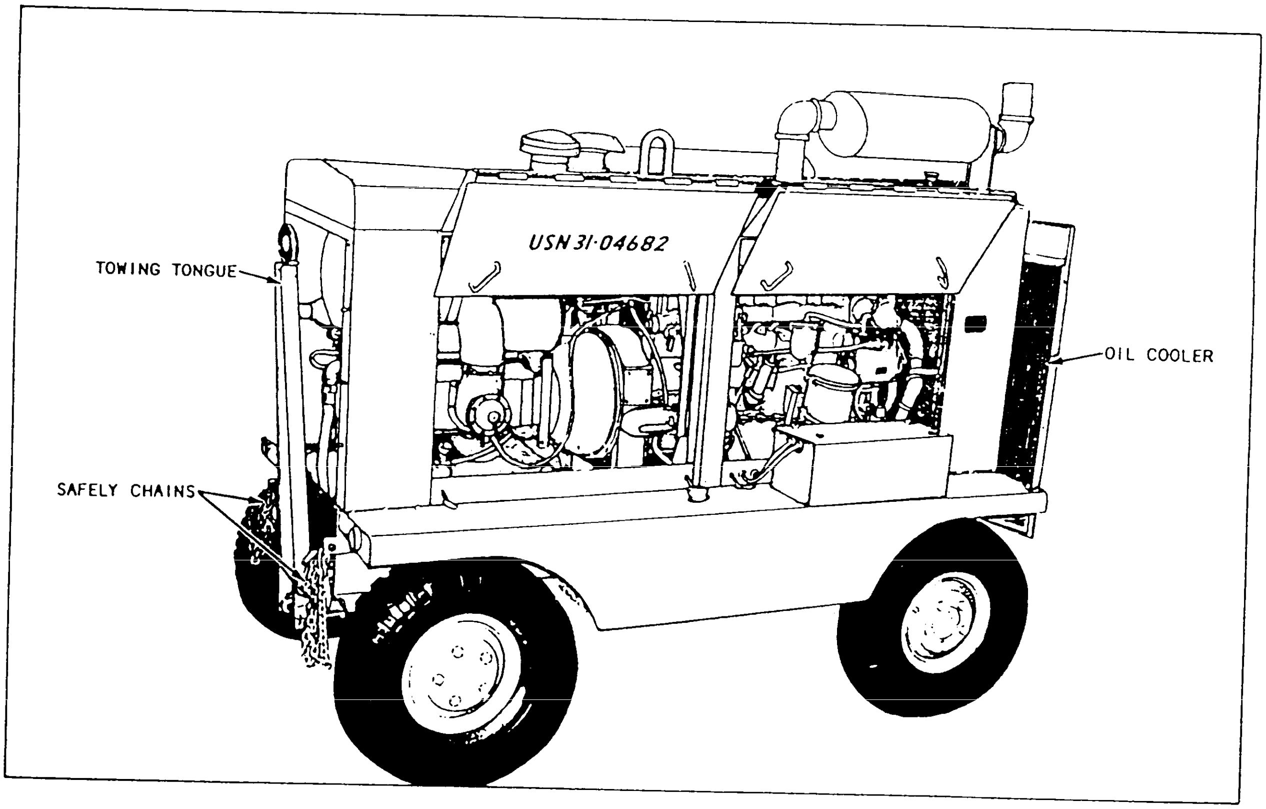


Figure 14-11.—Air compressor.

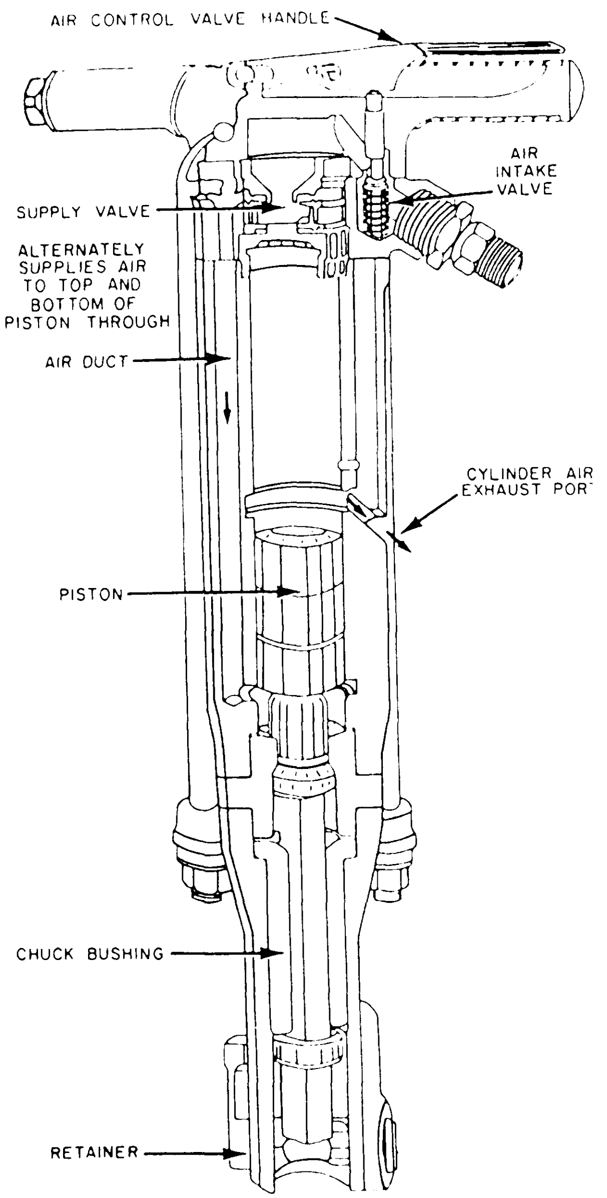

AIR CONTROL VALVE HANDLE
AIR INTAKE VALVE
SUPPLY VALVE
ALTERNATELY SUPPLIES AIR TO TOP AND BOTTOM OF PISTON THROUGH
AIR DUCT
CYLINDER AIR EXHAUST POR
PISTON
CHUCK BUSHING
RETAINER

Figure 14-13.—Pavement breaker.

Moil Point

The moil point is commonly used to break up pavement, rock, asphalt, or concrete. The moil point is a solid bar of case-hardened steel, pointed at one end, with a shank and upset collar at the other. The advantage of the moil point is its sharp point which allows it to first make a small hole that then slowly deepens and widens until the sides of the point are in full contact with the rock. The effect is like a wedge splitting an object.

Chisel Point

The chisel point is constructed like the moil point except for its point (fig. 14- 14). This point makes the chisel point the best to use for trimming corners and splitting seamed rock. Also, when you run into hardpan in trenching or at the bottom of a construction project, you can use the chisel point to slice off rock to reach the desired grade elevation.

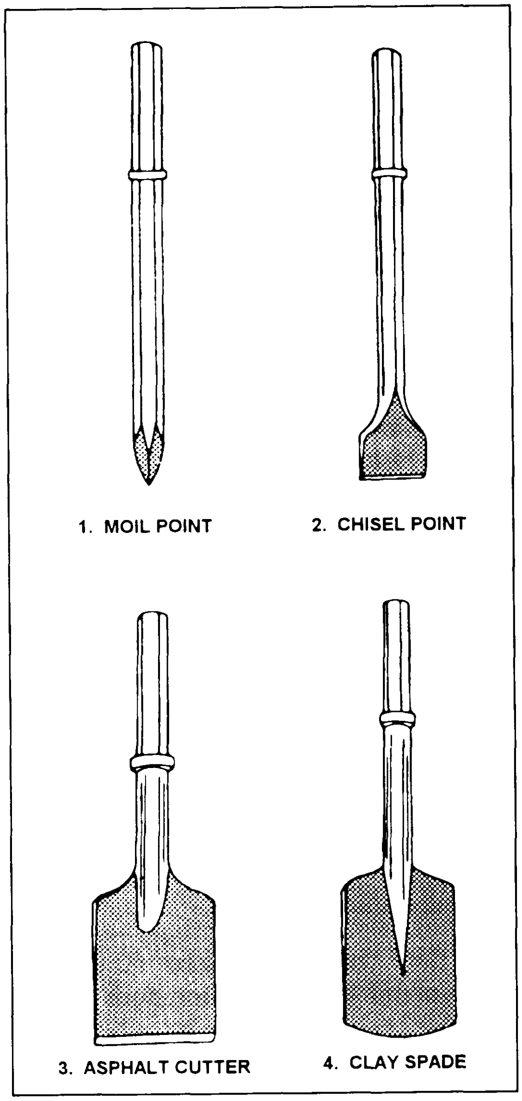

1. MOIL POINT
2. CHISEL POINT
3. ASPHALT CUTTER
4. CLAY SPADE

Figure 14-14.—Air hammer attachments.

Asphalt Cutter

The primary use of the asphalt cutter is to trim or cut the edges of laid asphalt, so major excavation will not harm the existing surface. One good example is asphalt patchwork.

Clay Spade

The clay spade is used for loosening compacted clay or dressing foundation edges.

HAND-HELD ROTARY ROCK DRILL/JACKHAMMER

The hand-held pneumatic rock drill/jackhammer (fig. 14-15) is a piston rotary unit that is designed mainly for use as a hard rock drill; however, it is equally efficient in soft and medium formations.

The components of the drill are shown in figure 14-16. The drill consists of a back head group, cylinder unit, and front head group. The back head group consists of the four-position throttle, handle, and live air inlet. The cylinder unit consists of a cylinder with a reciprocating piston. The front head group consists of the chuck, retainer latch, and anvil. The drill design directs air through the drill, down the drill steel, and into the bottom of the hole to blow out rock cuttings.

Four classes of rotary rock drills/jackhammers are as follows:

- The first class is a light drill, weighing about 15 pounds. This class is used for drilling shallow holes in quarry operations.
- The second class is a light drill, weighing 25 to 40 pounds. This class is used for light work, such as potholing and drilling concrete.
- The third class weighs from 40 to 50 pounds. This class is used for drilling in limestone and other soft rock.
- The fourth class is a hand-held drill, weighing from 50 to 65 pounds. This class is used for drilling holes up to 6 feet during quarry operations.

NOTE: All of these drills use hollow drill steel and are built with automatic rotation.

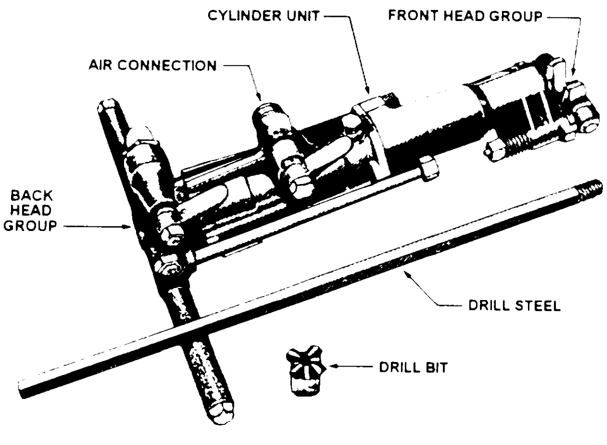

CYLINDER UNIT
FRONT HEAD GROUP
AIR CONNECTION
BACK HEAD GROUP
DRILL STEEL
DRILL BIT

Figure 14-15.—Hand-held rotary rock drill/jackhammer.

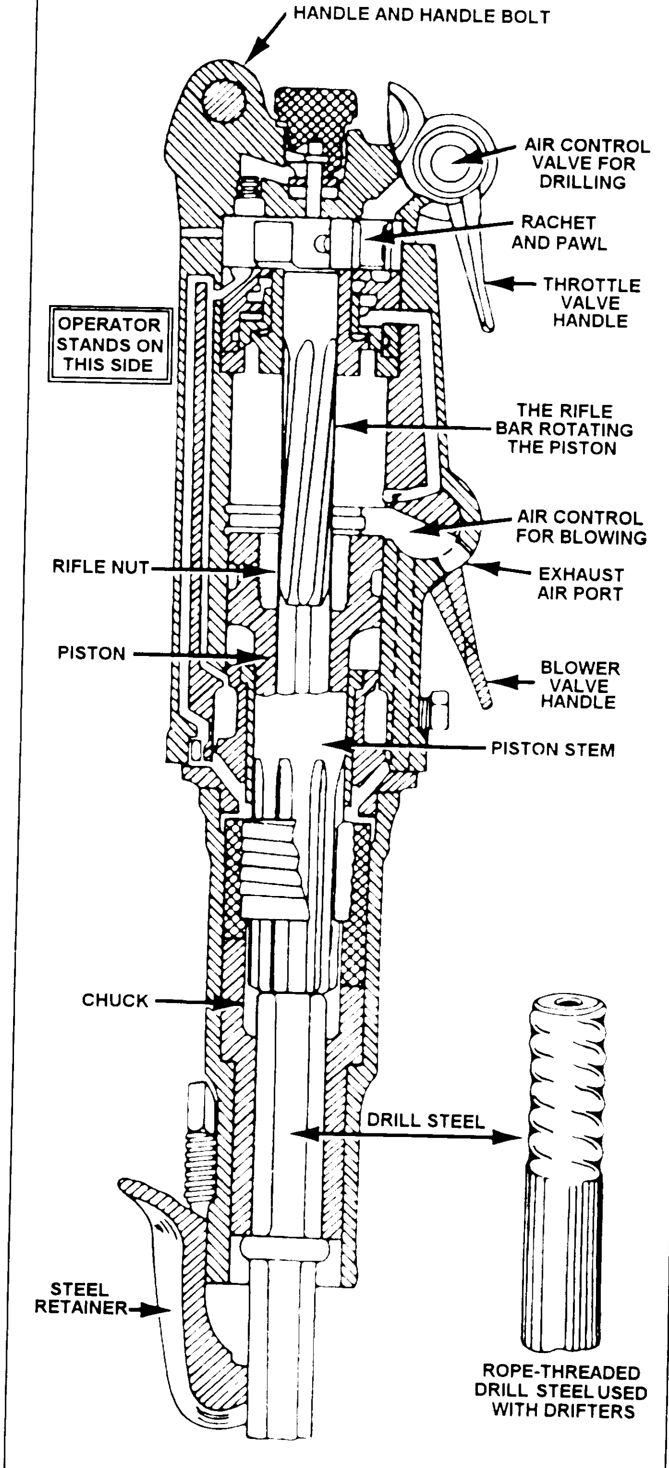

HANDLE AND HANDLE BOLT
AIR CONTROL VALVE FOR DRILLING
RACHET AND PAWL
THROTTLE VALVE HANDLE
OPERATOR STANDS ON THIS SIDE
THE RIFLE BAR ROTATING THE PISTON
AIR CONTROL FOR BLOWING
RIFLE NUT
EXHAUST AIR PORT
PISTON
BLOWER VALVE HANDLE
PISTON STEM
CHUCK
DRILL STEEL
STEEL RETAINER
ROPE-THREADED DRILL STEEL USED WITH DRIFTERS

Figure 14-16.-Components of a hand-held rotary rock drill/jackhammer.

Hand-held rotary rock drills used in quarry operations may be the dry drill, the blower drill, or the wet drill.

The **dry drill** allows very little air to pass through the drill steel while drilling; therefore, you should drill 30 seconds and blow 60 seconds. When the hammer is not running, the dry drill allows enough air to pass through for cuttings to be blown out of the hole. Drill steels for this drill comes in lengths of 2, 4, and 6 feet with tips made of carbon inserts, diamond, or star.

The **blower drill** allows a steady supply of air to pass through the drill steel to help remove cuttings from the hole while the hammer is running. This type also permits air to pass through ths drill steel when the hammer is not running.

The **wet drill** provides a constant supply of water through the drill steel while the hammer is running.

Lubrication

Most rock drill failures and complaints result from bad lubrication. Correct lubrication of rock drills depends on the following:

1. Selection of the proper lubricant
2. Application of enough lubricant for all working parts

The lubricant must have the correct viscosity for a uniform rate of feed under many temperatures. Besides being just viscous (thick) enough, a good rock drill oil must have the following:

1. High-film strength and the ability to withstand shock loads.
2. Not “blow” readily, or interfere with valve action.
3. Not fog, or exhaust toxic gases.
4. Not corrode under any operating condition.
5. Lubricate perfectly at maximum drill speed, at both high and low temperatures.
6. Not form gummy leftovers with either hot or cold air.

An in-line oiler must be used with each drill. Drill manufacturers recommend installing the in-line oiler within 10 to 12 feet from the drill. If the oiler is too far from the drill, oil droplets tend to gather on the inside of the hose. This condition results in sporadic delivery of oil to the drill and can result in serious damage to the drill.

Safety

Before operating the drill, ensure the drill steel and bits are in good condition. Drill steel center holes should be clear and the shanks should be flat and square, not chipped or rounded off. Rock bits should be sharp. Dull rock bits are hard on the drill and the operator. To avoid injury to yourself and fellow workers, operate the drill as follows:

- NEVER pound on stuck steel. Nothing is achieved, and you may damage the drill and bit.
- NEVER retract the steel at full throttle. This may damage the front head parts.
- NEVER strike the drill with teds. This may dent the cylinder or cause other damage.
- NEVER drag a drill along the ground, because the exhaust ports and other openings may scoop up dirt that will cause trouble and possible failure.
- Blow out the air supply hose and flush out the water hose before connecting it to the drill to rid the line of dirt.
- Ensure the drill is well-lubricated. Adjust the in-line oiler, so the steel shank always shows a film of oil.
- Keep the drill aligned with the drill steel and hole. Hold the drill firmly and apply even pressure with both hands.
- Keep all hands off the trigger or throttle until ready to start drilling operations.
- When drilling, keep your balance and NEVER get your face close to the drill.
- Wear safety shoes, safety glasses or impact goggles, gloves, hearing protection, and a hard hat.
- NEVER rest an air tool on the toes of your boots.
- NEVER point a drill at another person or start an air drill while it is laying on the ground.
- Do NOT use your body to control an active drill and never point an air hose at yourself or others.
- Always bleed the airline before removing it from the drill.

CHAIN SAW

The chain saw (fig. 14- 17) is a heavy-duty pneumatic device, designed primarily for cutting trees or timbers up to 24 inches in diameter during clearing operations. The chain saw is also used to accomplish heavy timber construction, such as bridges, bunkers, and culverts.

NAIL DRIVER

The pneumatic nail driver (fig. 14-18) is a lightweight member of the reciprocating percussion family of tools and used primarily for driving large nails, spikes, and driftpins in heavy timber construction. When the nail driver is equipped with the proper attachment, it may also be used for other purposes, such as riveting, shearing heads from bolts and rivets, and removing scale and rust from metal plates or objects.

DRILL

The pneumatic drill (fig. 14-19) is a heavy-duty low-speed tool, designed to drive ship auger type of drills. The pneumatic drill is used extensively in trestle bridges and other timber construction work where it is necessary to drill holes for bolts or pins.

CIRCULAR SAW

The pneumatic circular saw (fig. 14-20) is built for heavy-duty use on timber construction work and maybe used for ripping as well as crosscut sawing. When the circular saw is equipped with the appropriate abrasive disk, designed for the specific material to be cut, it may also be used to cut brick, stone, concrete, tile, and similar materials.

SAFETY

Safety rules for pneumatic tools are as follows:

- Keep your hands and fingers off the trigger or throttle until you are ready to start the tool.
- Always keep your balance.
- Never get your face close to the tool.

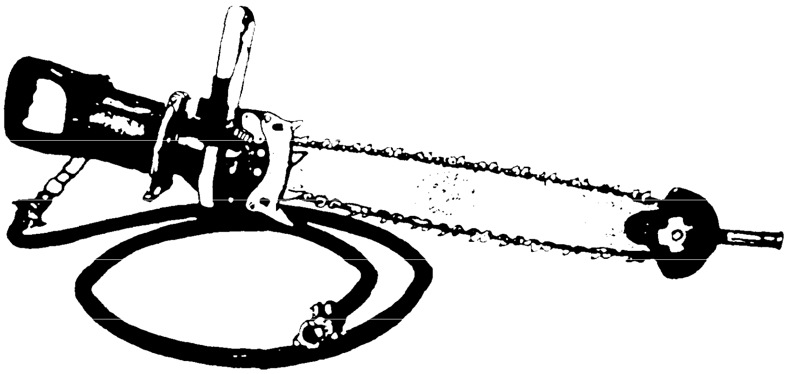


Figure 14-17.—Pneumatic chain saw.

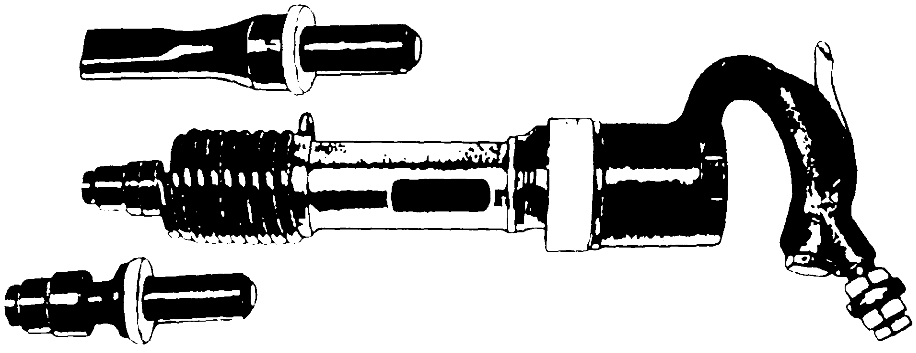


Figure 14-18.—Pneumatic nail driver.

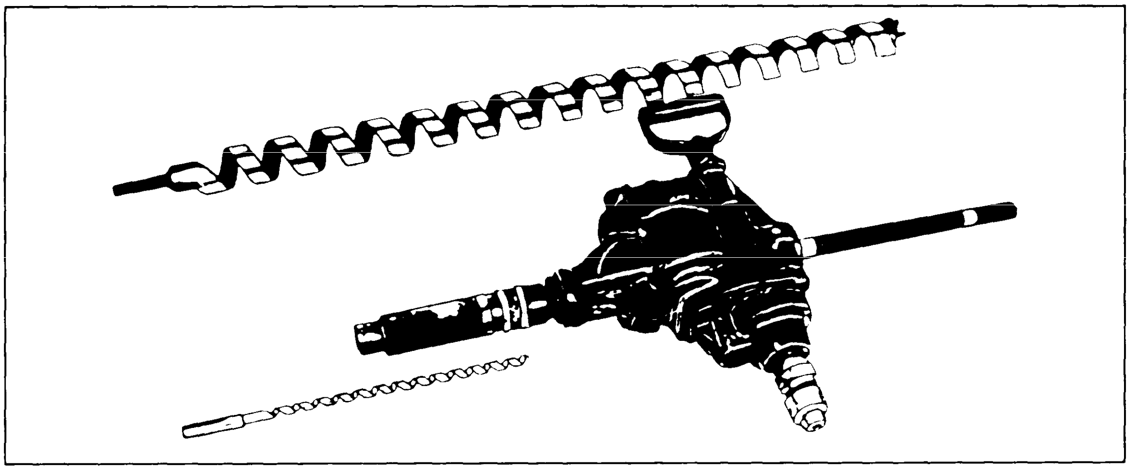


Figure 14-19.—Pneumatic drill.

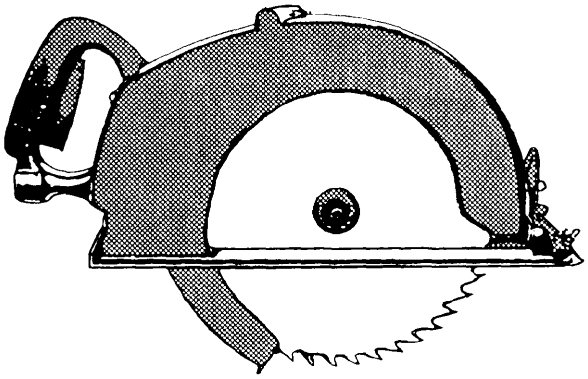


Figure 14-20.—Pneumatic circular saw.

- Wear safety shoes, safety glasses or impact goggles, gloves, hearing protection, and a hard hat.
- Never rest an air tool on your toes.
- Do not allow horseplay.
- Never point an air hose at yourself or others.
- Always keep both hands on the handle of the tool while operating.
- Always bleed the airline before removing it from the tool.

CRAWLER-MOUNTED ROCK DRILL

This section provides only the basic terminology and procedures used in rock drilling operations. The extensive knowledge and skills, required to perform as an effective rock drill operator, must be gained through formal training or on-the-job-training experience.

A component of quarry operations that contains all items of equipment needed to drill is the crawler-mounted rock drill (fig. 14-21). This drill is a self-propelled unit, designed primarily to drill vertical and angular blast holes in rock.

NOTE: Consult the operator's and maintenance's manual to obtain information on the type of rock drill you are assigned.

MAIN FRAME

The main frame is a steel fabrication, designed to withstand the strain imposed by operation over adverse terrain. The main frame provides a mounting base for the various components of the rock drill.

Track oscillation is controlled by two hydraulic cylinders, connected to brackets welded to both sides of the main frame and to brackets welded to the track frame. The cylinders permit 20-percent track oscillation, dampen sudden oscillation shocks when tramming over rough terrain, and stabilize the unit when setting up on uneven ground.

TRACTION DRIVE

The tracks are driven by a traction device that consists of a parking brake, an axial piston motor, a brake valve, and a planet gear reduction. The traction drive is equipped with spring-loaded, hydraulically released brakes. The brakes are released automatically when hydraulic fluid is directed to the motors to move the unit. The brake valve, located within each of the motors in the hydraulic circuit, prevents the unit from uncontrolled runaways on grades. Each brake is

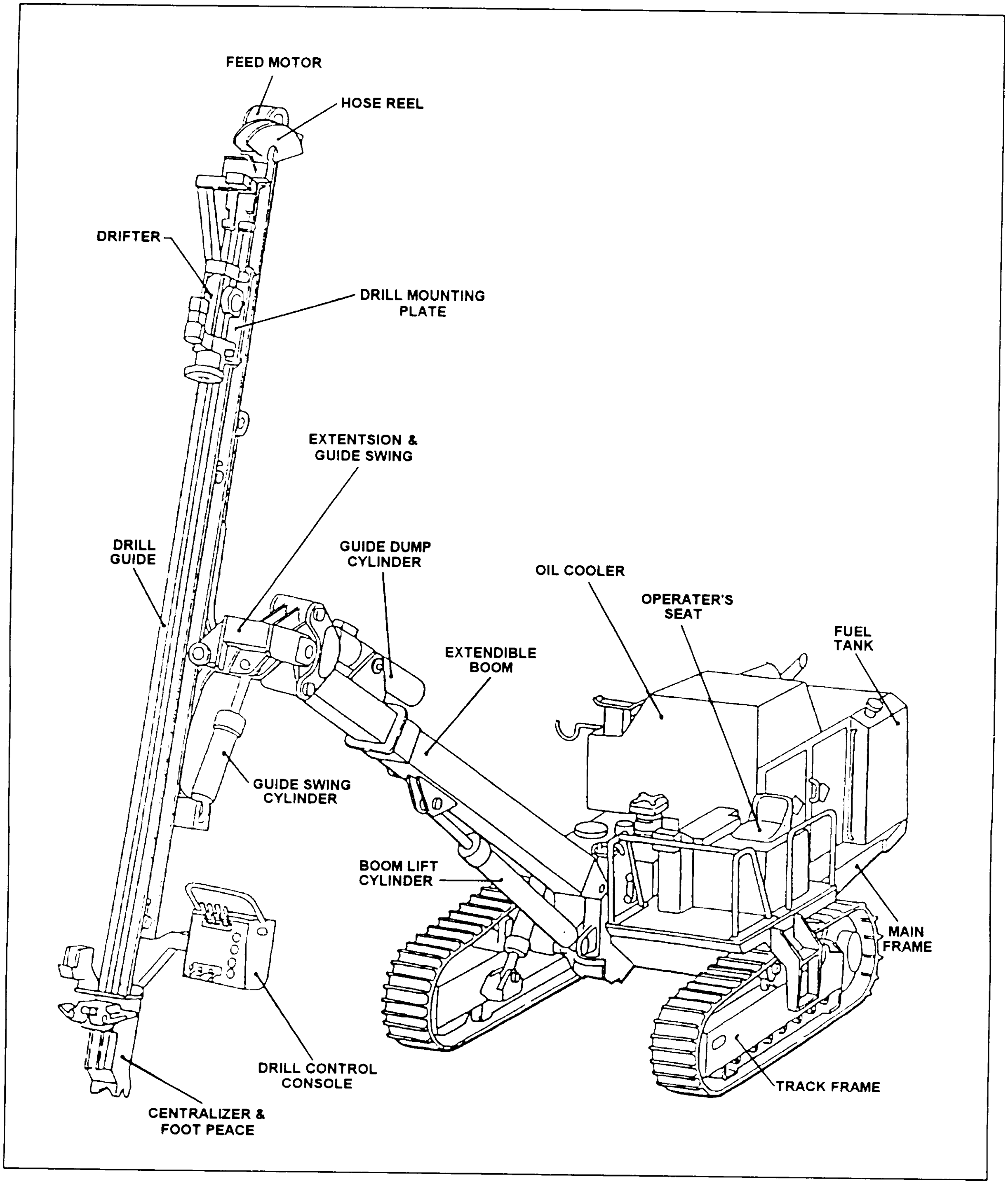

FEED MOTOR
HOSE REEL
DRIFTER
DRILL MOUNTING PLATE
EXTENTSION & GUIDE SWING
DRILL GUIDE
GUIDE DUMP CYLINDER
OIL COOLER
OPERATER'S SEAT
FUEL TANK
EXTENDIBLE BOOM
GUIDE SWING CYLINDER
BOOM LIFT CYLINDER
MAIN FRAME
DRILL CONTROL CONSOLE
TRACK FRAME
CENTRALIZER & FOOT PEACE

Figure 14-21.-Crawler-mounted rock drill.

controlled by the tram valve, mounted on the main frame.

POWER UNIT

The Power unit supplies the rock drill with hydraulic and pneumatic power.It consist of an engine four-coupled gear pumps, compressor air end, receiver tank, inlet manifold, return manifold, and hydraulic/ pneumatic piping.

Hydraulic System

The boom/guide set-up control valves and drill control valves are located at the side by the drill guide. Other control valves are located at the front side of the power unit, and the relief valves are located at the inside of the left door. The return and suction filters are located at the top of the hydraulic tank.

A pressure-compensated valve to change rod rpm according to drilling conditions is located at the inside of the left door.

The four pumps provide oil as follows:

- Pump one provides oil for right side tramming and slow and fast feed drilling.
- Pump two provides oil for left side tramming, drill, and fast feed.
- Pump three provides oil for high-speed tramming, rotation, and cooler.
- Pump four provides oil for high-speed tramming, dust collector, centralizer, cylinders, and auto rod changer (if so equipped).

Oil Cooler

The oil cooler maintains safe temperatures for hydraulic oil and compressor oil in all climates and is located at the top of the power unit. At low temperatures, the oil bypasses the coder through the cold bypass valve.

Air System

The air system consists of a compressor air end, receiver tank, blow air circuit, dust collector (if so equipped), and air lube system.

The air end is connected to the engine with a flexible coupling. The compressed air is delivered to the receiver tank, located at the backside of the power unit. The compressed air, mixed with compressor oil, is separated from the oil in the receiver tank and is distributed to each system. The separated compressor oil is sent to the oil cooler from the receiver tank under pressure. The compressor discharge air volume is 230 cfm, and the discharge air pressure is 100 psi.

NOTE: A common cause of low discharge air pressure is a clogged orifice muffler, located on the upper rear left comer of the rock drill.

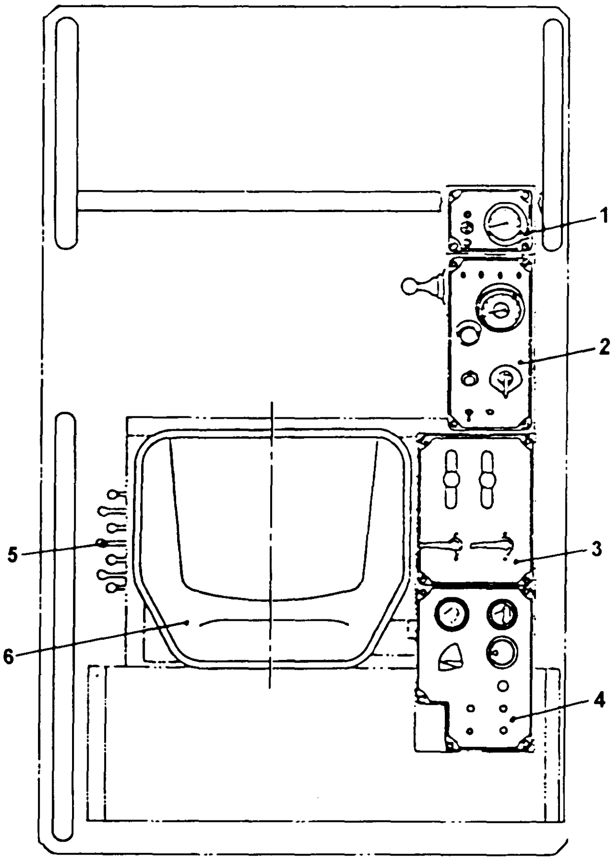
The dust collector is equipped with a stepping pulser that sends discharged air every 20 seconds to knock off the cuttings on the filter into the dropout chute, located at the bottom of the collector.

CONTROL CONSOLE

Controls on the drill guide are only for drilling and cylinder movement. All other engine controls, tramming valve, and cylinder valve are located around the operator's seat, as shown in figure 14-22.

BOOM

The rock drill is equipped with an expendable boom, commonly called a mast. The boom can vary 5 feet in length from the fully retracted to the fully extended position. The extendable booms are constructed of square steel tubing with a dump base holder at the front end and a clevis at the rear end. The clevis is hinged to a pedestal that is held in the boom base clevis by a kingpin.



1. **Start-Run Valve Panel**
2. **Engine Throttle Control Panel**
3. **Tramming Control Panel**
4. **Gauge and Electric Switch Panel**
5. **Hydraulic Cylinder Control Panel**
6. **Operator's Seat**

Figure 14-22.—Operator's control console.

The pedestal is free to rotate in the boom base clevis, and the boom is free to swing up and down in the pedestal; for example, the assembly is a universal joint that permits the boom to be swung from side to side or raised and lowered. A clevis, welded to the bottom side of the boom tube, supports the piston end of the lift cylinder, and a clevis, welded to the right side of the boom tube, supports the piston end of the swing cylinder.

DUMP AND SWING ASSEMBLY

The hydraulically powered dump and swing assembly is used to support and position the drill guide. The assembly permits 180-degree drill guide dump and 90-degree drill guide swing.

GUIDE SWING AND EXTENSION MOUNTING

The hydraulically powered guide extension assembly extends the drill guide for additional coverage or places the drill guide foot piece firmly against the ground for additional stability.

DRILL MOUNTING

The drill mounting consists of the drill guide, drill mounting plate, centralizer/foot piece, feed chain, feed motor assembly, and hose reel plate.

Drill Guide

The upper end of the guide is fitted with a hydraulic feed motor. A combination centralizer/foot piece is bolted to the lower end of the drill guide.

Drill Mounting Plate

The drill is mounted on a drill mounting plate that is clamped to and travels on the drill guide with the aid of four roller bearings.

Feed Chain

The drill guide is fitted with a heavy-duty roller chain for the drill mounting plate. The chain passes over a sprocket on the lower end of the guide and a drive sprocket in the feed motor on the upper end of the guide. The chain has two chain joints at both ends, connected at the bottom of the mounting plate with a link joint.

Feed Motor Assembly

The hydraulically powered feed motor assembly, which incorporates a planetary gear drive unit, is bolted at the upper end of the drill guide. A brake valve is installed in the hydraulic circuit just before the hydraulic feed motor. The brake valve absorbs the shock when the hydraulic feed motor receives a shock load and prevents spontaneous dropping of the drill. The feed motor feeds the drill through the feed chain and drill mounting plate up and down the drill guide. The feed motor is capable of exerting a maximum pull up of 4,410 pounds.

Hose Reel Plate

All the hoses for the drill are connected by way of the hose reel to the hose holder, which is attached to the right medium part of the drill guide.

TRAVELING

To travel the crawler-mounted rock drill over long distances, place the drill guide in a horizontal position, as shown in figure 14-23. When traveling in a drill pattern, keep the drill guide in a vertical position.

Traveling with the rock drill, using the tramming control panel (fig. 14-24), is as follows:

1. Forward: Push both tramming control levers forward.

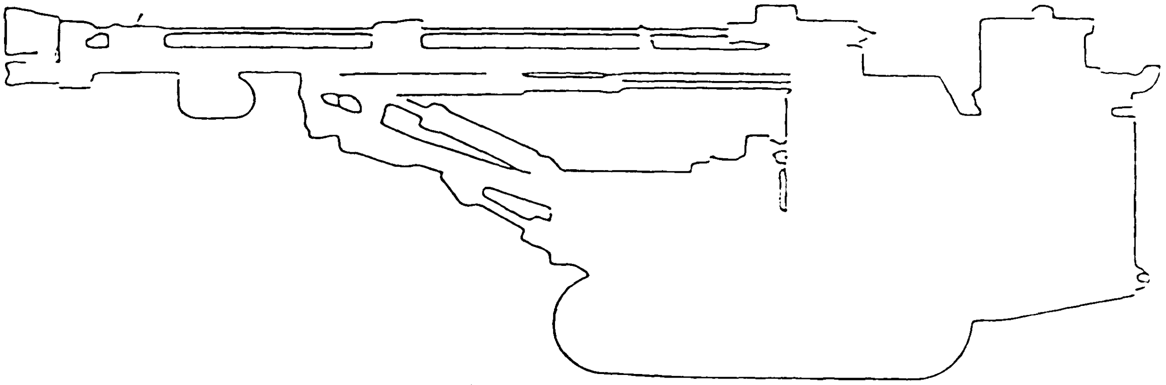
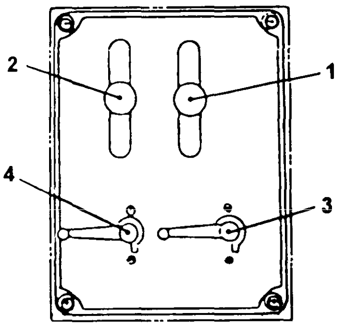


Figure 14-23.—Rock drill travel position.



1. **Right Hand Tramming Lever**
2. **Left Hand Tramming Lever**
3. **Right Hand Oscillation Lock Handle**
4. **Left Hand Oscillation Lock Handle**

Figure 14-24.-Tramming control panel.

2. Backward: Pull both tramming control levers backward.

3. Pivot turn: Push the right or left tramming control lever forward, and the unit pivots as the opposite track works as a fulcrum.

4. Right turn: Push the left tramming control lever forward and pull the right tramming control lever backward.

5. Left turn: Push the right tramming control lever forward and pull the left tramming control lever backward.

6. Speed adjustment: The speed is controlled by adjusting the forward angles of the tramming control levers.

7. Stop: To stop the rock drill, release the tramming control levers. When the levers return to the neutral position, the machine stops automatically. At the same time, the parking brake works. After completion of traveling, lock the levers.

NOTE: When working in tight areas, stay aware of your surroundings, ensuring all personnel stay clear of the rock drill when traveling and turning.

DRILLING

Drilling with the rock drill is performed from the drilling control console (fig. 14-25).

The functions of the components of the drilling control console are as follows:

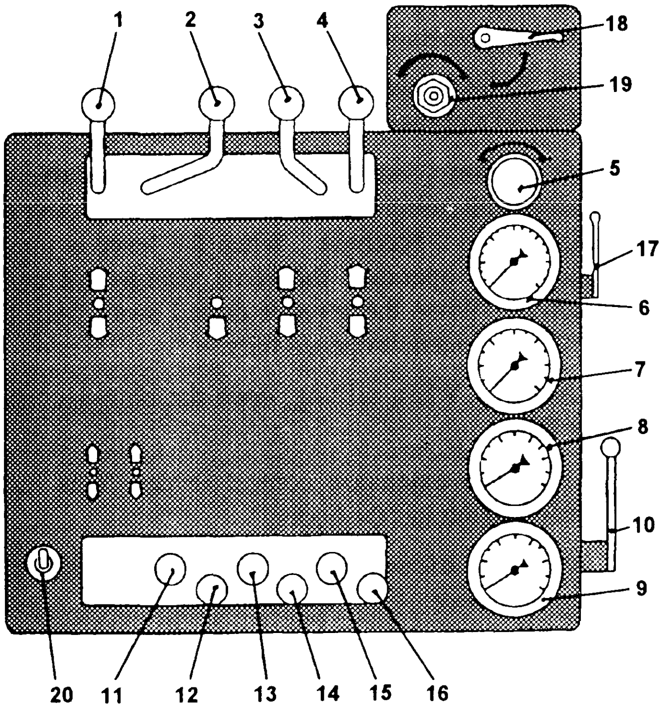


Figure 14-25.—Drilling control console.

1. Fast feed control lever: This lever is used for cleaning the hole and for changing steel. When pushed, the drill moves forward at fast speed. When pulled, the drill moves backward at fast speed. The lever returns automatically to neutral when released.

2. Drill control lever: This lever controls the percussion of the drifter. The drill pressure becomes higher in proportion to the position of the lever.

3. Rotation control lever: his lever controls the forward or backward rotation and rotation speed of the drill steel.

4. Slow speed control lever: This lever is used when drilling boreholes and coupling and uncoupling drill steel. When pushed, the drill steel moves forward at a slow speed. When pulled, the drill steel moves backward at a slow speed.

5. Feed pressure adjusting control valve: This control valve adjusts the feed pressure speed during drilling. When you pull and turn the knob to the right, the feed force increases. When you turn the knob to the left, the feed pressure decreases.

6. Feed pressure gauge: This gauge indicates the amount of discharged feed air pressure.

7. Drill pressure gauge: This gauge indicates the drill pressure during drilling.

8. Rotation pressure gauge: This gauge indicates the rotation pressure during drilling.

9. Blow pressure gauge: This gauge indicates discharged air pressure.

10. Blower control lever: This lever controls the amount of air going through the drill steel to clear the cuttings from a borehole. When the lever is turned towards the operator, the blow volume increases gradually. When the lever is turned away from the operator, the valve is opened fully.

NOTE: When drilling, open the blower control lever fully.

11. Boom extension control lever: This lever extends and retracts the boom.

12. Boom lift control lever: This lever raises and lowers the boom.

13. Boom swing control lever: This lever swings the boom left or right.

14. Guide dump control lever: This lever controls the 180-degree forward and backward movement of the drill guide.

15. Guide swing control lever: This lever controls the swing of the drill. The maximum swing of the drill guide is 45 degrees to the left and 45 degrees to the right.

16. Guide extension control lever: This lever extends the drill guide for an additional extension of up to 5 feet.

17. Anti-jamming system on-off control valve: During operation, the anti-jamming system assists in keeping the drill steel from jamming in a borehole.

18. Vaposol system on-off valve: During operation, from a 40-gallon storage tank, the vaposol system throws a mist of water down the drilled hole to control dust. It can also be used while drilling to prevent a cave-in from loose material in a borehole.

19. Needle valve: The needle valve controls the amount of water to be injected into the blow air.

20. Panel lamp switch.

Positioning for Drilling

Positioning the rock drill is performed as follows:

1. Position the rock drill by using the traction levers.

2. Place the crawler chassis in a horizontal position, when possible, by using the track oscillation levers, and then set the oscillation lock handles to the drilling position to keep the rock drill stable while drilling.

NOTE: The drill operator should approach marked boreholes straight on as much as possible.

3. Position the drill guide over the spot to be drilled.

4. Extend the guide down until the second or third track roller is just off the ground. Position the drill guide inward towards the rock drill to compensate for the pressure and angle of the boom when in position for drilling.

5. Before drilling, you must ensure the guide is vertically level by using a builders level on the front and side.

Drilling Operation

Before drilling, make sure the blow air pressure gauge indicates 100 psi. Drilling procedures are as follows:

1. Open the blow control lever to admit air through the drill steel and bit.

NOTE: Two types of drill bits, used in thr NCF, are the roller bead and carbide insert.

2. Start **forward** rotation by pushing the control lever toward the console.

3. Push the drill lever toward the console to start the drifter conclusion.

4. Push the slow feed lever to collar the hole. Collaring should be carried out by alternately moving the feed lever up and down until the bit has penetrated 3 to 4 inches into solid rock.

NOTE: Make sure the hole does NOT deflect from the desired hole direction.

5. After a successful collar is made, push the rotation lever and the blow lever all the way, then push the feed lever.

NOTE: Speed of drilling and rotation is automatic according to the density of the rock formation. The harder the rock, the faster the unit will drill. Use the control lever for the desired speed.

CAUTION

Pay attention to the vibration of the hydraulic hose in the drill. If the hose vibrates abnormally, the accumulator of the drill is damaged or the gas pressure has dropped abnormally due to a gas leakage.

Pay attention to the yawing of the drill mounting. Violent yawing of the drill mounting is caused by improper feed pressure. Adjust the feed force by using the feed pressure adjusting valve.

NOTE: Improper feed pressure shortens the life of the feed chain, the rod, the sleeve, and the shank. It also results in poor penetration rates.

ADDING EXTENSION RODS.— Components of the rock drill, used when adding or removing extension rods, are shown in figure 14-26.

Adding extension rods, commonly called drill steel, is performed as follows:

1. Feed the drifter down and hold the coupling on top of the centralizer. Engage the drifter hammer until the coupling is loose.

2. Reverse rotate and allow the drifter to back out of the coupling, then run the drifter to the top of the drill guide. Be sure to grease the drifter shank or tamper bar, and ensure the coupling remains on the drill steel down in the borehole.

3. Attach another coupling to the drifter shank or tamper bar. Add additional drill steel; forward rotate until all is coupled.

4. Lift the coupling off the centralizer. Then open the centralizer and continue drilling until the coupling has completely passed the centralizer. Once the coupling has passed, close the centralizer around the drill steel.

REMOVING EXTENSION RODS.— Once the rock drill has reached the desired depth, removing the extension rods is performed as follows:

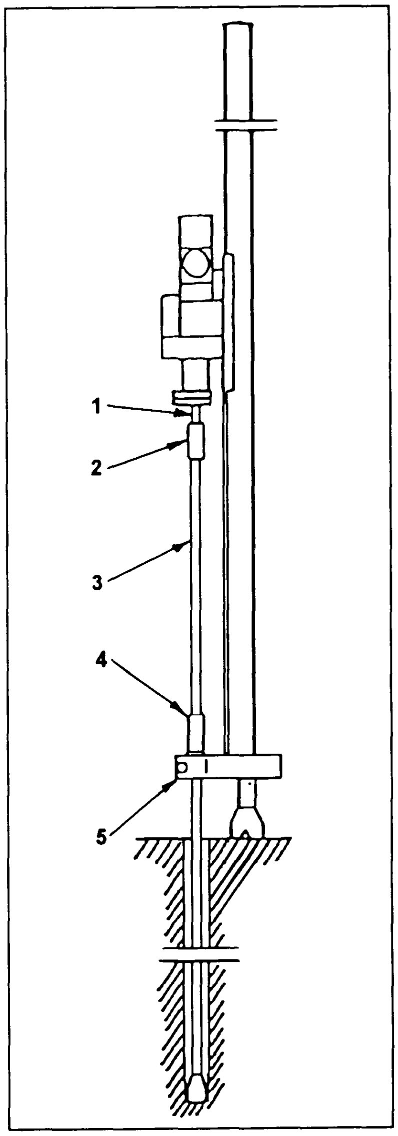
1. Clean the hole completely before removing the drill steel.

2. Move the rotation control lever to the neutral position to stop rotation.

3. Place the coupling on top of the centralizer, and allow the drill to hammer on the shank to loosen the coupling threads.

4. Shut off the drill.

5. Reverse rotate the steel from the coupling.



1. **Shank**
2. **Coupling**
3. **Rod**
4. **Coupling**
5. **Centralizer**

Figure 14-26.-Components of the drill guide.

NOTE: Keep an eye on the coupling that connects the drill shank to the drill steel. This coupling will work loose faster than the lower coupling and could fall.

6. Run the drifter down to the coupling that is resting on the centralizer.

7. Forward rotate the drifter into the coupling.

8. Run the drifter with the attached coupling and drill steel to the top of the drill guide. To remove

successive sections of the drill steel, you repeat the steps as outlined.

NOTE: Clean and lubricate all drill steel sections and coupling before storing.

After drilling four consecutive boreholes, the drill steel should be rotated or changed.

SAFETY

Personnel, involved in rock drilling operations, must adhere to the safety guidelines outlined in the *U.S. Army Corp of Engineers, Safety and Health Requirements Manual,* EM 385-1-1. Additional safety precautions are as follows:

- Safety equipment, such as double-hearing protection, safety goggles, respiratory protection, hard hats, gloves, and safety boots, must be worn by all personnel that are involved in rock drilling operations.
- Remember to retract the foot piece of the drill guide from the drilling face before moving the drill rig. Failure to do so can cause extensive damage to the hydraulic components of the drill guide.
- Never use reverse rotation of the drill to break tight or stuck coupling joints.
- Do NOT allow personnel, other than the operator, to ride on the rock drill.
- Do NOT operate the drill with the coupling resting on the centralizer arms.
- Do NOT move the drifter rotation control lever from forward to reverse without first stopping the drill.
- When securing the drill, position the drill guide in a 90-degree vertical position.
- When the operator is operating the rock drill from the operator's seat, all personnel must stay clear of the drill control console,
- Visitors, unless suited properly with all safety gear, must stay clear of rock drilling operations at a distance of no less than 50 feet.
- Secure all drilling operations during thunderstorm conditions.
- Use gloves when handling drill steel, couplings, and bits. These components get extremely hot when used in rock drilling operations.

MISCELLANEOUS CONSTRUCTION AND MAINTENANCE EQUIPMENT

Floodlights, generators, lubricators, pumps, sweepers, and snow removal equipment are categorized as miscellaneous construction and maintenance equipment. This equipment is listed under the registration series USN 50-00000.

FLOODLIGHTS

The floodlight unit (fig. 14-27), commonly known as a light plant, is intended for field use in all climates. Being self-contained, it is especially suited for use in remote locations as an emergency floodlight source.

Components

The light plant unit consists of an engine generator set, portable floodlights, extension cords, floodlight mounts, and a grounding rod. The floodlights, extension cords, floodlight mounts, and the grounding rod are all accountable collateral gear, assigned to each unit; therefore, it is important that these components are returned and stored in their assigned light plant. All of the components are mounted on a two-wheel trailer, covered by a weatherproof sheet metal housing.

Mounting provisions for the floodlights are provided inside the housing. The floodlights swivel in different positions for distributing light over a large area. Extension cords are supplied for using the floodlights away from the unit. Special plugs are used on these extension cords that are for use only with the floodlight.

NOTE: Do NOT run power tools from a light plant. The power surge and power draw from these tools can overload the exciter and result in damage to the generater.

Operation

Before placing the light plant in operation, make sure the unit is grounded, using the grounding rod and grounding cable. Additionally, ensure the light plant is positioned suitably for adequate operating room and ventilation for dissipation of engine heat and exhaust. Remove the number of floodlights and cables required and place them in the desired locations. Plug the cables into the output receptacles.

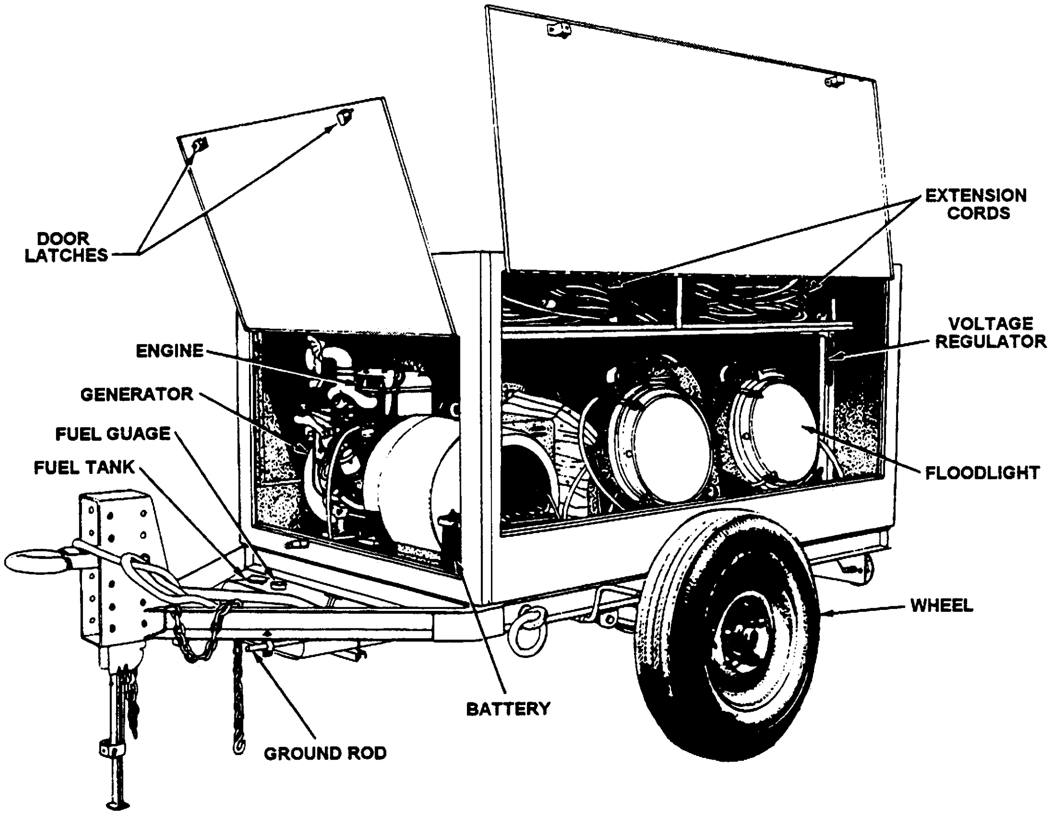


Figure 14-27.—Floodlight unit.

CAUTION

Do NOT idle the engine with the generator excited. If the engine is idled with the generator excited, excessive field current may burn out the generator field winding.

Safety

Safety is a vital part of floodlight operation. Many floodlight safety practices are simple and obvious. Major safety precautions applicable to floodlight operation and care are as follows:

- Always pipe exhaust fumes outside when operating a floodlight unit in an enclosed area.
- Always ground the unit before it is placed into operation.
- Always stop the unit before servicing with fuel or lubricants.

CAUTION

Do NOT shut the engine down when the generator is under load. If you are not qualified to secure the generator, find someone who is.

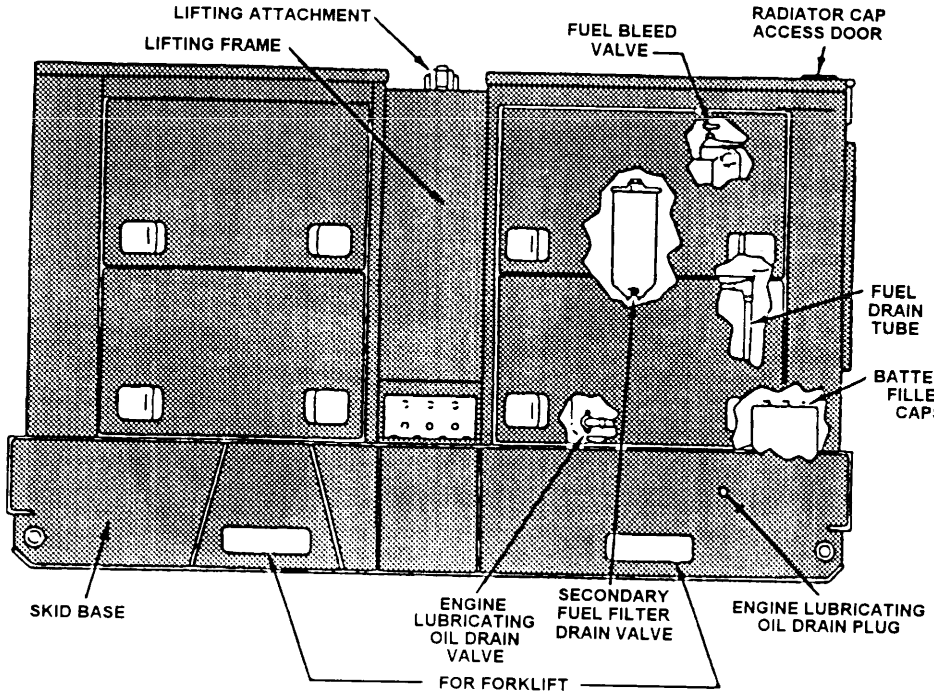
- Do not allow extension cords to contact sharp objects, oil or grease, hot surfaces, or chemicals.
- Extension cords should not be allowed to kink or be left where they might be run over.
- Replace damaged cords. They are NOT to be patched with tape.
- Store cords in their proper place, coiled loosely.
- Wear hearing protection when in the vicinity of a running generator.
- Do not attempt to install, hook up, or place any electrical apparatus when your hands are wet or when you are wearing wet clothing or shoes.
- Whenever it becomes necessary to check a circuit, have a Construction Electrician (CE) do this with appropriate testing equipment.

GENERATORS

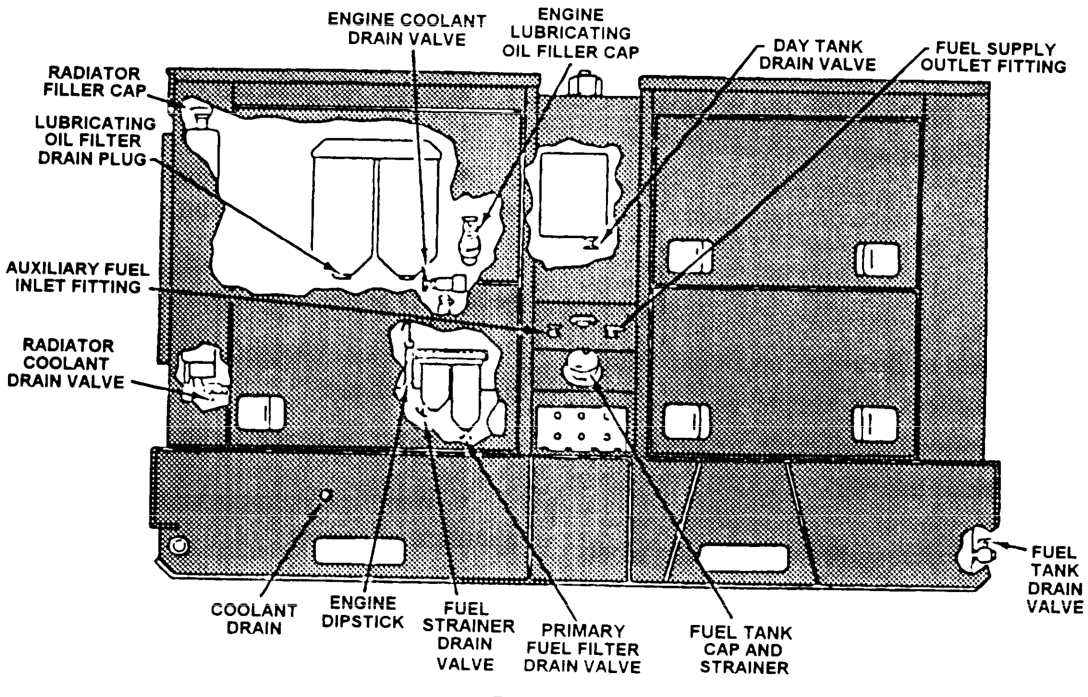
The generator (fig. 14-28) is a combination of an engine and an electric generator that converts mechanical energy into electrical energy. Most generators in the NCF range in size from 5 kilowatt (kW) to 200 kW. Generators in these sizes range in weight from 488 pounds to 10,500 pounds. They are mounted on skid bases, and lifting and tie-down eyes are provided.

Operation

The CEs normally make the selection of a generator, based on the electrical demands, the voltage phase, and


LIFTING ATTACHMENT
LIFTING FRAME
FUEL BLEED VALVE
RADIATOR CAP ACCESS DOOR
FUEL DRAIN TUBE
BATTERY FILLER CAPS
SKID BASE
ENGINE LUBRICATING OIL DRAIN VALVE
SECONDARY FUEL FILTER DRAIN VALVE
ENGINE LUBRICATING OIL DRAIN PLUG
FOR FORKLIFT

A. RIGHT SIDE


ENGINE COOLANT DRAIN VALVE
ENGINE LUBRICATING OIL FILLER CAP
DAY TANK DRAIN VALVE
FUEL SUPPLY OUTLET FITTING
RADIATOR FILLER CAP
LUBRICATING OIL FILTER DRAIN PLUG
AUXILIARY FUEL INLET FITTING
RADIATOR COOLANT DRAIN VALVE
FUEL TANK DRAIN VALVE
COOLANT DRAIN
ENGINE DIPSTICK
FUEL STRAINER DRAIN VALVE
PRIMARY FUEL FILTER DRAIN VALVE
FUEL TANK CAP AND STRAINER

B. LEFT SIDE

Figure 14-28.—Generator.

the frequency requirements. When selecting a site to set up a generator, keep in mind that the noise level of the generator may present a problem in low-noise level or quiet areas. For example, the operating 100-kW generator presents a noise hazard that exceeds the allowable limits for unprotected personnel in the immediate area; therefore, all personnel in the immediate area must wear single- or double-hearing protection.

Other factors to consider when selecting a site to set up a generator are as follows:

1. Placing a generator near points of large demand reduces the size of the wire required, holds the line loss (voltage) to a minimum, and provides adequate voltage control at the remote ends of the line.

2. The generator must be placed on a stable, preferably level, foundation. It should NOT be operated on an incline of more than 15 degrees from level.

3. In an area where the ground is soft, stabilize the foundation with wood planking, sand bags, or other materials to provide a firm foundation for the generator.

Although generators are designed to be operated outdoors, prolonged exposure to wind, rain, and other adverse conditions will shorten their lives. When generators are to remain on site for any extended period of time, they should be mounted on solid-concrete foundations and installed under some type of shelter.

Grounding

The generator set must be connected to a suitable ground before operation.

WARNING

Electrical faults in the generator, load lines, or load equipment can cause injury or electrocution from contact with an ungrounded generator.

Various types of grounding systems are used, such as an underground metallic water piping system (fig. 14-29, view A), a driven-metal rod (fig. 14-29, view B), or a buried metal plate (fig. 14-29, view C). A ground rod must have a minimum diameter of 5/8 inch if solid and 3/4 inch if pipe. The ground rod must be driven to a minimum depth of 8 feet. A ground plate must have a minimum area of 2 square feet and, where practical, be embedded below the permanent moisture level.

NOTE: The ground rod is accountable collateral gear for a generator.

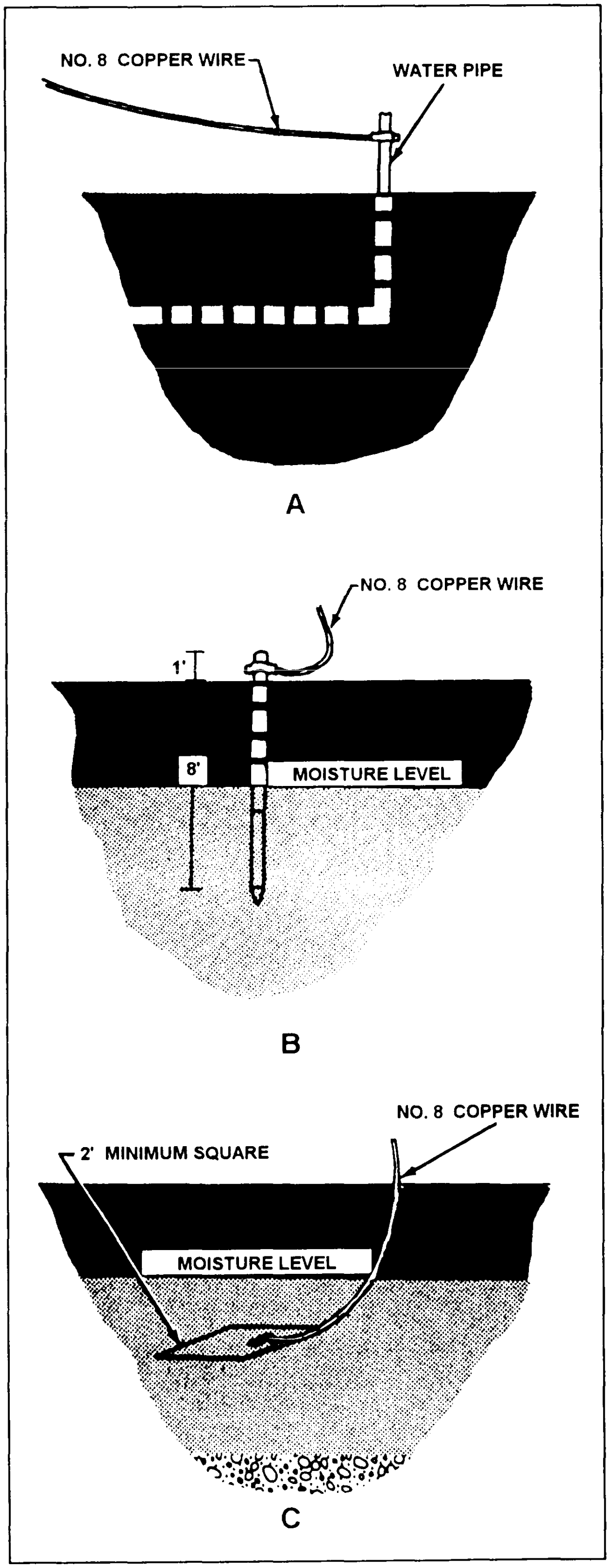


Figure 14-29.—Methods of grounding generators.

The ground lead must be at least No. 8 AWG (American Wire Gauge) copper wire. The lead is bolted or clamped to the rod, plate, or piping system. The other end of the lead is connected to the generator set terminal stud, as shown in figure 14-30.

Generator Watch

Anytime a generator is placed into operation, a generator watch should be established. The primary purpose of the generator watch is to produce power in a safe responsible manner, notice any maintenance or repair problems of the generator that require immediate attention, and ensure the generator does not run out of fuel. The CEs normally handle the responsibilities of a generator watch.

Cleaning

Cleaning of the generator requires only cleaning of dirt, grime, and grease off the protective covering, the engine department, the batteries, and the skid base.

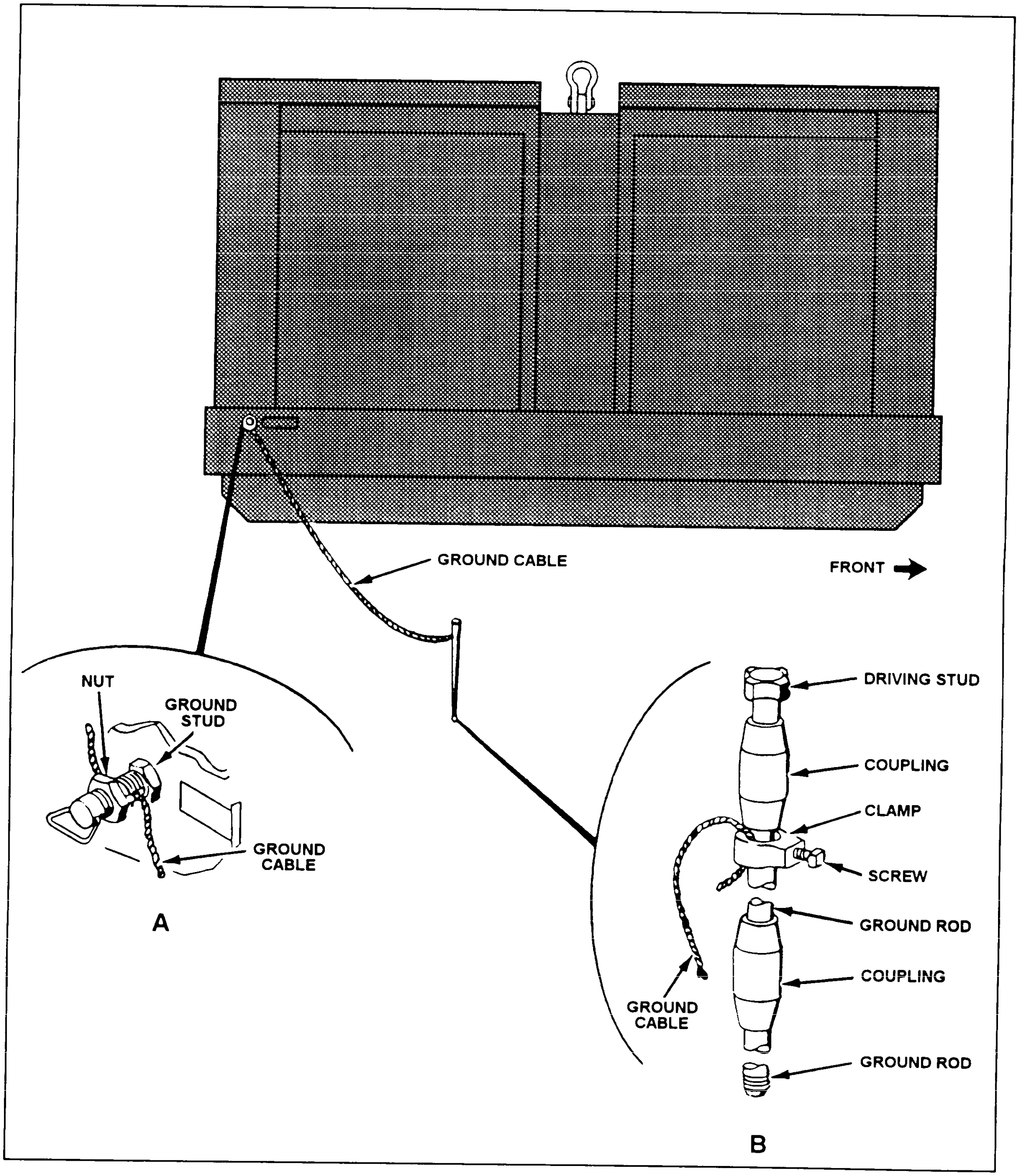

GROUND CABLE
FRONT
NUT
GROUND STUD
GROUND CABLE
A
DRIVING STUD
COUPLING
CLAMP
SCREW
GROUND ROD
COUPLING
GROUND CABLE
GROUND ROD
B

Figure 14-30.—Grounding procedure.

NOTE: All components shown in figure 14-31 marked with an asterisk should **NOT** be pressure-washed because excessive water will cause moisture damage. The only method to clean these components is to wipe them down with clean rags.

LUBRICATORS

The most common lubricators, used in the NCF, are portable skid-mounted (fig. 14-32) or truck-mounted.

When automotive and construction equipment is being used on a project site some distance from the maintenance shop, the portable self-contained lubricator can be used to save time and expense involved in moving the equipment long distances to be lubricated and serviced.

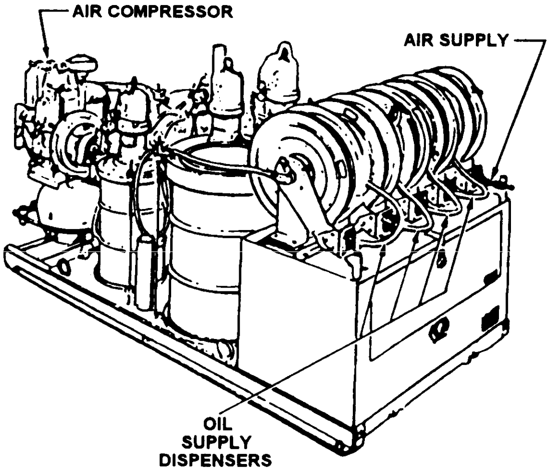
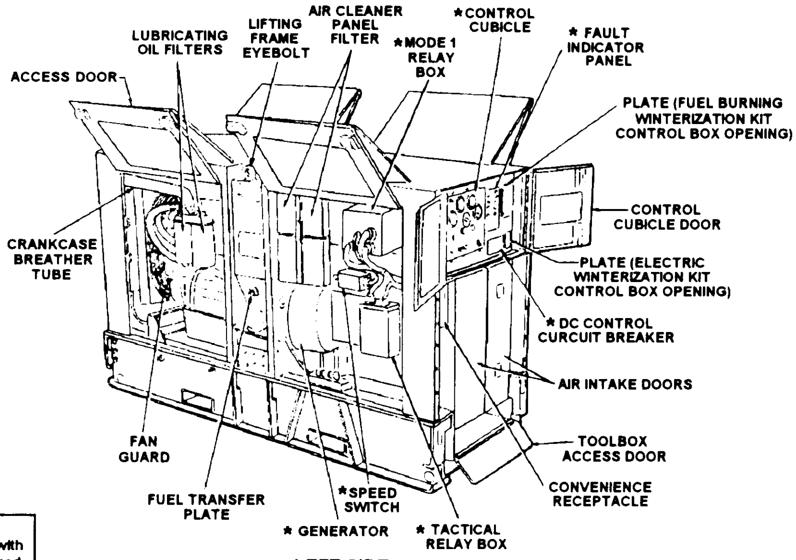
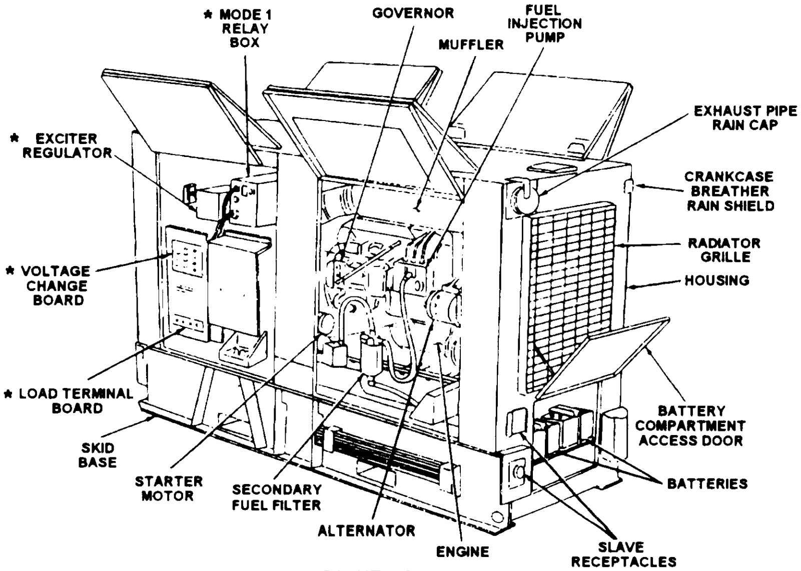

AIR COMPRESSOR
AIR SUPPLY
OIL SUPPLY DISPENSERS

Figure 14-32.—Skid-mounted lubricator.


AIR CLEANER PANEL FILTER
LIFTING FRAME EYEBOLT
LUBRICATING OIL FILTERS
*CONTROL CUBICLE
*MODE 1 RELAY BOX
* FAULT INDICATOR PANEL
ACCESS DOOR
PLATE (FUEL BURNING WINTERIZATION KIT CONTROL BOX OPENING)
CONTROL CUBICLE DOOR
CRANKCASE BREATHER TUBE
PLATE (ELECTRIC WINTERIZATION KIT CONTROL BOX OPENING)
* DC CONTROL CURCUIT BREAKER
AIR INTAKE DOORS
TOOLBOX ACCESS DOOR
FAN GUARD
CONVENIENCE RECEPTACLE
*SPEED SWITCH
FUEL TRANSFER PLATE
* GENERATOR
* TACTICAL RELAY BOX

LEFT SIDE

NOTE:
Components marked with an * are not to be cleaned with a pressure washer.


* MODE 1 RELAY BOX
GOVERNOR
FUEL INJECTION PUMP
MUFFLER
EXHAUST PIPE RAIN CAP
* EXCITER REGULATOR
CRANKCASE BREATHER RAIN SHIELD
RADIATOR GRILLE
* VOLTAGE CHANGE BOARD
HOUSING
BATTERY COMPARTMENT ACCESS DOOR
* LOAD TERMINAL BOARD
SKID BASE
BATTERIES
STARTER MOTOR
SECONDARY FUEL FILTER
ALTERNATOR
ENGINE
SLAVE RECEPTACLES

RIGHT SIDE

Figure 14-31.—Components of a generator.

Uses

To **grease fittings,** pull out the length of hose you need, wipe the fitting clean, and push the coupler of the control valve onto the fitting. Squeeze the valve lever. When grease is forced out, release the lever and twist the coupler to one side to remove it. Do not try to pull it straight off. After servicing is complete, wipe the control valve coupler clean, rewind the hose, and put the control valve into its holder.

NOTE: When greasing, follow the manufacturer's lubrication chart to ensure all grease fittings are greased at the proper intervals.

NOTE: Be careful not to overgrease, as overgreasing can cause damage to seals and packings.

NOTE: Wipe up any excessive grease that can fall onto the deck of the equipment or onto components that do not require greasing.

In dispensing motor or gear oil, pull out the necessary length of hose, clean all dirt off the fill hole plug and surrounding area, and then remove the plug. Check to see that the meter is on zero, insert the control valve nozzle into the fill hole, and squeeze the valve lever. After the required quantity of motor or gear oil has been dispensed, release the lever. Reinstall the plug you removed earlier. Clean the control valve nozzle, reset the meter to zero, turn counterclockwise, and store the hose and valve.

For **gauging and inflating tires,** an air gauge with two sizes of air chucks is in the storage cabinet. The gauge has a pin fitting that snaps into the air hose coupler. When inflating tires, release the gauge lever to check the pressure of the tire; depress to inflate the tire.

Safety

- Always have a firm metal-to-metal contact when filling the fuel tank.
- Never stand directly in front of a tire when it is being inflated. Stand to one side.
- Always pipe the exhaust fumes to the outside when operating the lubricator in an enclosed area.
- Never fill the fuel tank while the engine is running.
- Never direct a jet of compressed air at yourself or anyone else.
- Always stop all operations of a unit before servicing it.
- Always use Navy-approved solvents for cleaning.
- Always relieve all pressures before servicing any component of the lubricator.
- Always check the engine and the compressor crankcase oil level at the start of each workday.
- Always review the Material Safety Data Sheet (MSDS) for every hazardous material, fuel, lubricant, and solvent before use for precautions and hazards.
- Always dispose of greases, oils, and contaminated materials in an environmentally responsible manner.

PUMPS

A pump uses the mechanical energy produced by its prime mover to move liquid from one point to another. The pump moves the liquid by either pushing, pulling, or throwing. Pumps are often named or classified by the action that causes fluid movement; for example, diaphragm or centrifugal.

Regardless of its design or classification, each pump has a power end and a liquid end. The **power end** is some form of prime mover, such as an electric motor, internal combustion engine, or steam turbine. In steam-driven pumps, the power end is often referred to as the steam end. The basic purpose of the power end is to develop the mechanical motion or force required by the liquid end.

In the liquid end, mechanical motion, developed by the prime mover, is exerted on the liquid. This part of the pump must allow for suction (where the liquid enters the pump) and for discharge (where the liquid leaves the pump). The liquid end is often referred to as the pump end, the water end, or the oil end to show the nature of the substance pumped.

Diaphragm Pump

The diaphragm pump (fig. 14-33) uses a flexible diaphragm to move liquid. The prime mover is usually a small gasoline engine with an eccentric connecting rod arrangement that converts rotary motion to reciprocating motion. On the suction stroke, the diaphragm is drawn upward into a concave configuration. This movement of the diaphragm results in a partial vacuum that causes the suction ball valve to

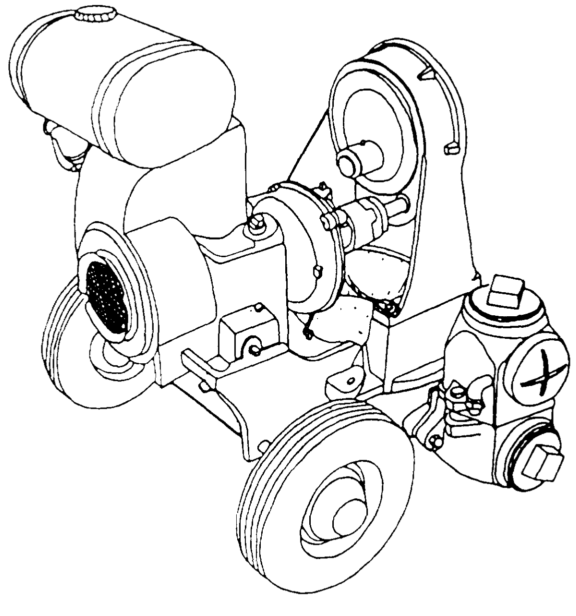


Figure 14-33.—Diaphragm pump.

unseat (and at the same time keeps the discharge ball valve seated) and to admit liquid to the pump cylinder. On the discharge stroke, the diaphragm is pushed downward forcing the trapped liquid out through the discharge valve. Thus the liquid is made to move by the reciprocating motion of a flexible diaphragm.

Since the diaphragm forms a tight seal in the pump cylinder between the liquid being pumped and the rest of the pump and driving mechanisms, there is little danger of liquid abrasion or corrosion of moving parts behind the diaphragm.

NOTE: Diaphragm pumps are especially well-suited for pumping mud, slime, silt, and other wastes or heavy liquids containing debris, such as sticks, stones, or rags.

Liquid strainers are fitted at the suction inlet to prevent large objects from fouling the suction and discharge valves or possibly damaging the diaphragm.

You may have to use the diaphragm pump for such duties as dewatering trenches where sewer lines or waterlines are to be laid, dewatering cofferdams or cave-ins, or repairing breaks in water or sewage lines. Two of the most popular types of diaphragm pumps are the **mud hog** (closed discharge) and the **water hog** (open discharge).

The mud hog is for jobs that require pumping heavy and thick liquids that must be discharged at a distance away from the pump. The pump is fitted with discharge hose connctions, and the ball valves and chambers are designed to prevent fouling by sticks, stones, or rags.

The water hog is used for pumping thinner or less viscous liquids. It can handle liquids containing sand, gravel, or mud. The discharge outlet from the water hog is open to permit free flow and to increase discharge capacity. The liquid is discharged directly at the pump. A discharge hose, however, can be fitted to the pump if desired, but the hose connection can reduce the efficiency of the pump.

You must know the operation of the diaphragm pump. Since nearly every job presents a different problem, you may have to vary the operating procedure to fit the individual job.

Before starting the pump, place the suction line and screen in the liquid to be removed by the pump. Construct a trough to drain the pump discharge away from the pump.

OPERATION.— Start the engine first. If the pump does not pick up the liquid in a minute or two, check the suction line for leaks. You can do this by pouring water over the hose connections. In the event there is a leak, air bubbles will appear.

Should the connections be tight and no leaks appear, check the diaphragm for cracks or punctures. If the diaphragm is damaged, it has to be replaced. A mechanic inspector must make any further inspections.

INSPECTION.— Because of the nature of the liquids handled by diaphragm pumps, inspection during pump operation becomes particularly important. Inspect the suction inlet strainer often to avoid accumulations of debris that reduce suction efficiency. Most diaphragm pump installations also permit easy access to the suction and discharge ball check valves. These valve mechanisms should also be inspected frequently to detect scoring, fouling, and improper valve seating.

NOTE: Sand, gravel, and other material can corrode the diaphragm and ball check valves; expect these parts to require the most frequent operator inspections.

Centrifugal Pump

The basic centrifugal pump has only one moving part: a wheel or impeller that is connected to the drive shaft of a prime mover and that rotates within the pump casing. The impeller is designed to impart a whirling or revolving motion to the liquid in the pump. When the impeller rotates at relatively high speeds, sufficient centrifugal force is developed to throw the liquid outward and away from the center of rotation. Thus the liquid is sucked in at the center, or eye, of the impeller (center of rotation) and discharged at the outer rim of the impeller.

The centrifugal pump, like the diaphragm pump, is driven by a single-cylinder, four-cycle, air-cooled gasoline engine. To operate the engine properly, you should be familiar with its controls.

NOTE: Refer to the operator's manual for specific instructions for the type of pump you are operating.

OPERATION.— The operation of centrifugal pumps is generally similar to the operation of diaphragm pumps. Centrifugal pumps (fig. 14-34) are also fitted with stuffing boxes and various types of bearings that require periodic operator's maintenance and inspection.

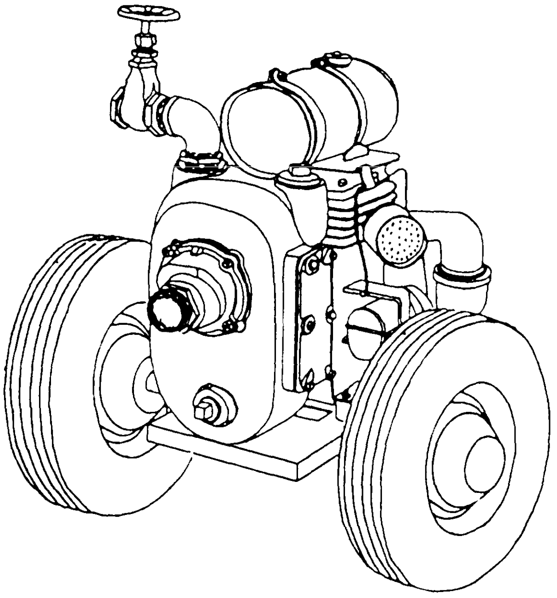


Figure 14-34.—Centrifugal pump.

NOTE: Unlike positive displacement pumps, the discharge stop valve on centrifugal pumps must be closed before starting the pump.

The reason for closing the stop valve is to allow the pump to work against the sealed discharge and buildup an effective pressure head before attempting to move and distribute the liquid downstream. After the pump is up to speed and the discharge valve is opened, it will continue to maintain that pressure head unless the operating conditions change.

There is no danger of building excessive pressure while the pump is running with the discharge closed. If the centrifugal pump were permitted to continue operation with the discharge sealed, it would simply build up toward its maximum discharge pressure and then begin to churn the liquid; that is, the discharge pressure would overcome the suction pressure and the liquid would continually slip back to the suction side of the pump. Nothing more would happen, except that the pump would build up heat since the liquid would not be able to carry away heat generated by the moving parts.

INSPECTION.— There is little for you to inspect other than routine operator's maintenance. If you follow all of the operator's manual instruction and the pump does not function properly, call for a field mechanic or turn it in to the dispatcher with a hard card for repair.

SWEEPERS

Many different types of sweepers are used in the Navy. Some of the most common are the towed sweeper, the street sweeper, and the magnetic sweeper.

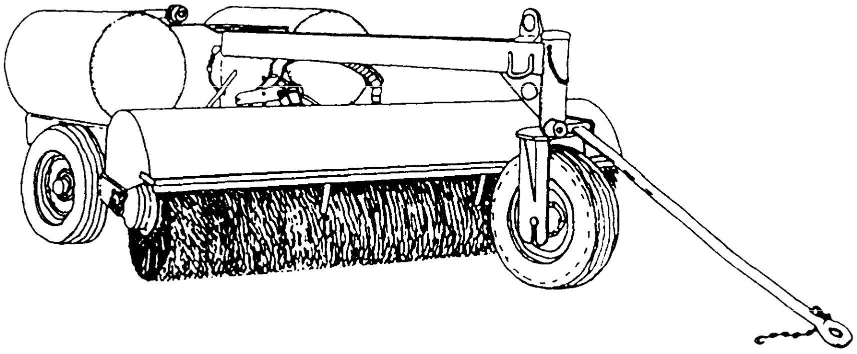


Figure 14-35.—Towed sweeper.

Towed Sweeper

The NCF primarily uses the towed sweeper (fig. 14-35). Its size and easy maintenance give it an advantage over the street sweeper. Its disadvantage is that it requires a prime mover and windrows the debris to one side or the other only and does not pick it up.

Street Sweeper

The Navy also uses different types and makes of street sweepers, the most common being the self-propelled type. The self-propelled street sweeper (fig. 14-36) is used mainly to remove loose debris from the surface of streets, roads, parking areas, taxiways, and airport runways.

Operational procedures to adhere to when operating a street sweeper are as follows:

- During sweeper operations, you should plan ahead and select routes where water is available to refill the water tank of the sweeper. This effort saves time and the expense of having to travel long distances to refill.

- The sweeper is equipped with a prime mover, controls, and devices for controlling movement of the basic machine for steering, sweeping, and water spraying, as well as for picking up, containing, and disposing of debris.

- When refueling a street sweeper, make sure the engine is turned off and see that metal-to-metal contact is maintained with the fuel tank and fuel nozzle.

- Keep personnel away from the brushes and scrubbers of the sweeper during operation

- Always stop operations when adjusting, cleaning, and lubricating the equipment.

- Keep hands clear of drive chains.

- Park the sweeper on level ground with the hand brake applied.

- Except in emergencies, do not turn the steering wheel sharply when the machine is in motion. The sweeper is highly responsive to small movements of the steering wheel.

Magnetic Sweeper

The magnetic street sweeper is used primarily to pick up metal debris magnetically, such as iron and steel scrap, from traffic areas. The John Deere tractor model

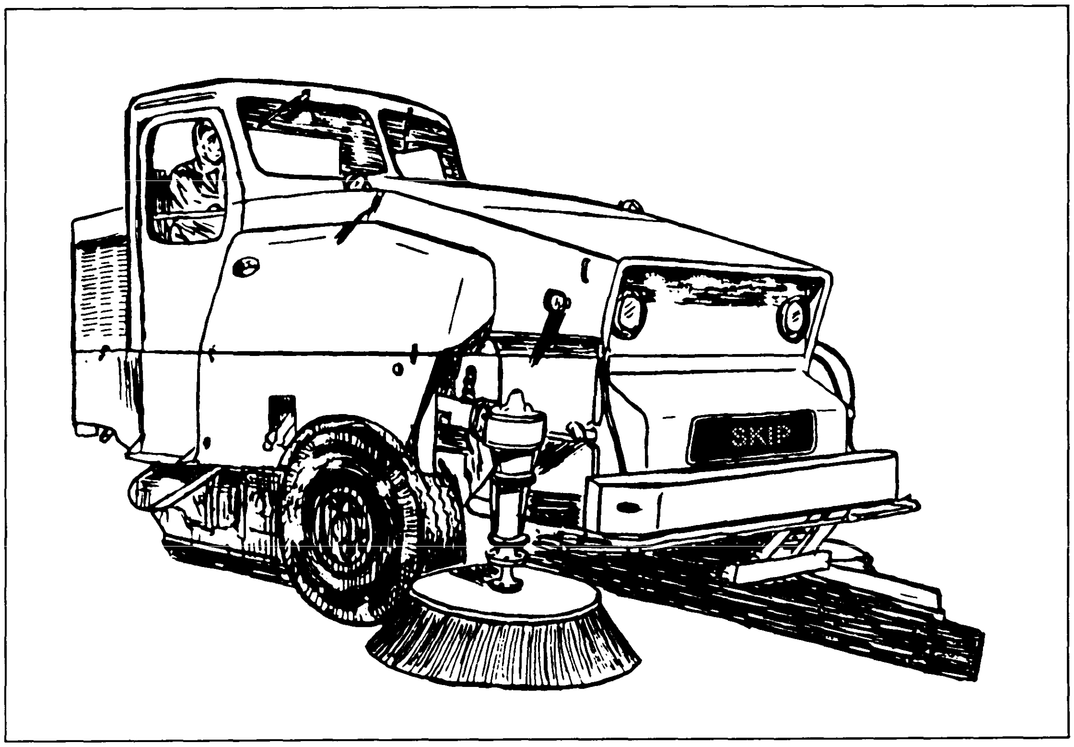


Figure 14-36.—Street sweeper.

(fig. 14-37) is one of many different makes and models of self-propelled magnetic sweepers used by the Seabees. This type of sweeper is most effective in warehouse and storage areas and on granular or earth surfaces that cannot be cleaned with broom equipment.

Under normal conditions, using the magnetic sweeper around work areas one or two times a week will keep areas free of metal debris. If construction or demolition is in progress, the magnetic sweeper should be used as often as needed to keep areas free of metal debris. Using the magnetic sweeper helps prevent flat tires on wheeled equipment.

By positioning the hydraulically controlled lever, the operator can adjust the height of the magnet for the type of surface being swept.

Heavy springs and a bumper, mounted on the front of the magnet, help prevent magnet damage when an obstruction is encountered during operation. The springs act to lift the magnet over obstructions and return the magnet to its previous position.

After sweeping an area be sure to take the magnetic sweeper to an assigned trash area, dump the debris collected by shutting off the magnetic circuit breaker, and place the debris in the container provided.

When refueling a magnetic street sweeper, make sure the engine is shut off, and see that metal-to-metal contact is maintained with the fuel tank and fuel nozzle.

Perform the following when operating the magnetic sweeper:

- Allow no riders.
- Stop operations when adjusting, cleaning, and lubricating the unit.
- Do not drop material from the magnet and then run the sweeper over the material. Pick up the material and dispose of it before securing the sweeper.

SNOW REMOVAL EQUIPMENT

Snow and ice removal operations are affected by many factors. Examples are as follows: availability of suitable equipment, skill and experience of personnel, mission of the activity, geographical location, and type and severity of the weather.

An efficient snow and ice removal operation must have competent direction and supervision; however, the final operation depends largely upon the skill, experience, and training of the operators.

Snow removal equipment comes in a variety of shapes, sizes, and types. The equipment can range from common push plows (sometimes called displacement plows), graders, loaders, and sand spreaders to sophisticated blower types of equipment.

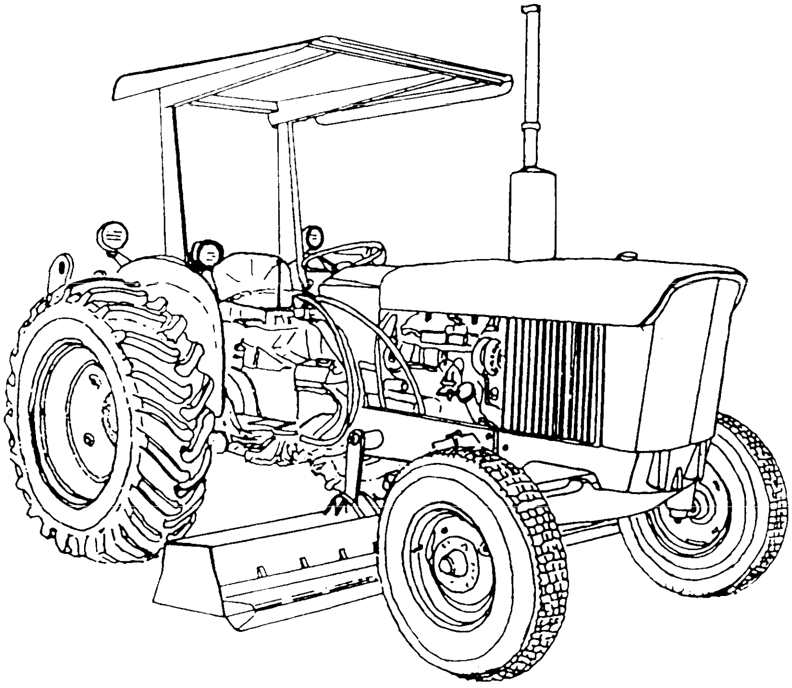


Figure 14-37.—Magnetic sweeper.

Plows

The plow is the most commonly used in snow removal operations. Push plows are commonly referred to as blades because of their different configurations. Three types of snow plow blades are the reversible, rollover, and combination.

REVERSIBLE BLADE.—A reversible blade (fig. 14-38) is a snowplow blade that can be positioned to bulldoze snow straight ahead or angled to throw snow to the right or left. This is a smaller type of blade and is generally mounted on light trucks.

Reversible plows are most efficient for clean-up work or for use in restricted areas where you desire to change the angle of the blade, rather than dead ahead. These plows are also good for removing light snow from roads, walks, platforms, and storage areas. Reversible plows are intended for slow-speed operation and will not remove snow as effectively as other plows; however, they can be used to plow airfield pavements, even if they move less snow than other plows.

ROLL-OVER BLADE.— A roll-over blade (fig. 14-39) can plow snow to either side. It has a tapered moldboard, formed to give snow a lifting, rolling action and can throw snow a considerable distance at fairly high speeds. To change from right to left, raise the plow as high as it can go and (as the name implies) roll the plow over. The toe will remain at the bottom of the arc, and the heel will be the top of the arc.

NOTE: Come to a complete stop to prevent damaging the plow when rolling the blade over.

There is only a few inches of clearance when the blade passes the center. After you roll the blade over and before you begin another pass, return the blade hoist lever to the float position to allow the plow to follow the contour of the pavement.

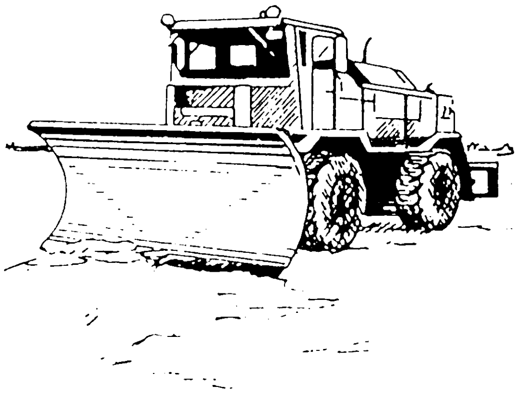


Figure 14-38.—Reversible blade.

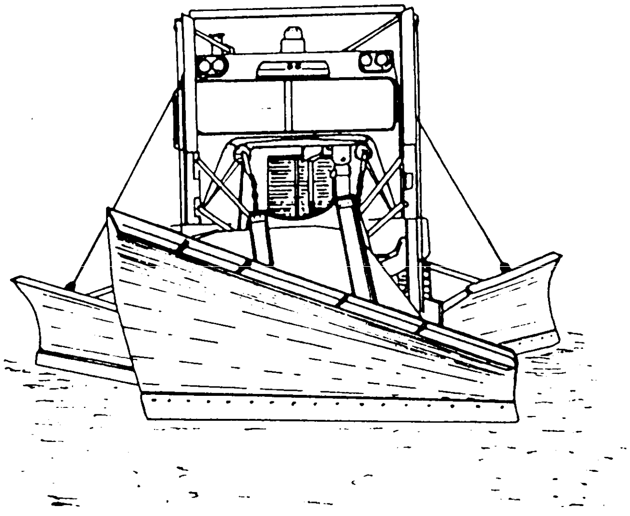


Figure 14-39.—Roll-over blade.

The maximum speed at which snow removal equipment is allowed to operate varies with each military installation. Whenever possible, you should drive a roll-over snowplow 20 to 30 miles per hour (mph) to get good action off the end of the blade. If you drop the speed down to less than 20 mph, the snow does not have enough rolling action when it comes off the end of the blade, resulting in a high windrow.

On the other hand, if you maintain a speed of 20 mph or more, the snow will be thrown off the end of the blade and be scattered thinly. When plowing windrows with a roll-over plow or a reversible or a combination blade, you can keep your speed up by taking less than a full blade of snow or by drifting out of the windrow until you regain your speed and then pulling back into the windrow.

COMBINATION BLADE.— A combination blade (fig. 14-40) can be used in either of three of the following positions:

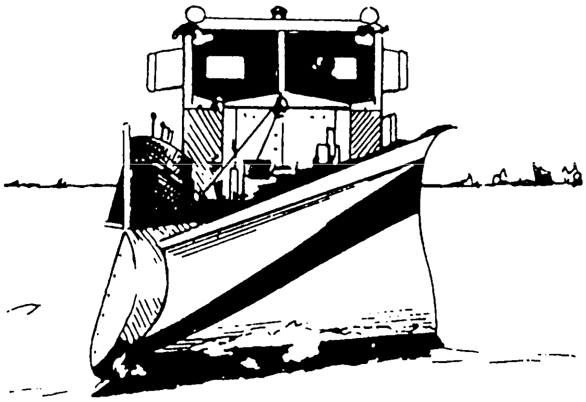


Figure 14-40.—Combination blade.

1. Straight ahead
2. Angled to the right
3. Angled to the left

When the combination blade is angled to either side, it throws snow to that side.

The combination blade is usually used as a V-plow when the first pass is made to open the center of a wide pavement. After this, it is angled to throw the snow to the right or left, depending on the direction the traffic travels on the road. If the pavement is short, it will take longer to reverse the blade angle than it will to deadhead for another pass to the right.

Blowers

Augers on a snowblower (fig. 14-41) feed snow into high-speed augers, rotors, or fans that blow the snow a great distance.

The fan and augers are powered by an auxiliary engine independent of the truck engine. This power is transmitted from the rear (auxiliary) engine to the augers and fan by a drive shaft between the engine clutch assembly and the blower assembly. This has a shear pin that will break any time the blower assembly gets an object in it that will not pass through the blower. In some instances, the fan and each auger have a shear pin instead of the drive shaft having one.

Aircraft chocks, fire extinguishers, and rocks are three of the items that break many shear pins and cause much damage to blowers. Movable items should be removed before snowstorms. Once they are covered with snow, they can be picked up with the snow and jammed into the blower fan and shear pin and damage the blower.

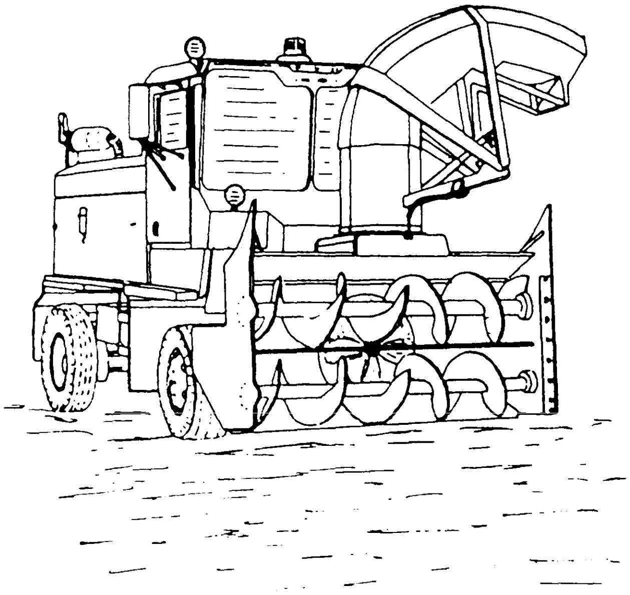


Figure 14-41.—Snowblower.

On the other hand, rocks may not do much damage to the blowers, but when they are blown out of the blower, they may hit aircraft or equipment or even people. If you must blow snow where there are rocks, raise the blower a couple of inches off the ground to prevent picking up too many rocks.

Engaging the blower clutch too fast, engaging it with the rear engine running too fast, or engaging it with the blower assembly clogged with snow will shear a pin. Remember that the shear pin is a safety device to prevent breaking any other part of the blower. For this reason, you should carry extra shear pins with you when operating a blower.

The blower is for removing snow that is too deep to be plowed or that has been plowed into windrows. The chute on the top in the center above the fan is for directing the flow of snow. This chute can be rotated to blow the snow to the right or left. Snow is usually blown to the right. It can also be extended to control the angle and distance that the snow is blown. If you adjust the chute properly, snow can be blown into trucks to be hauled away.

Blowers are operated by throttling the auxiliary engine to full-governor speed and by adjusting the truck speed so the blower operates at full capacity. When the truck speed is too fast, the blower will clog and shear a shear pin. A foggy discharge will result when the truck speed is too slow. When the truck speed is just right, the snow is compressed by the fan and the discharge from it pulsates. One good way to tell when you are operating to capacity is by a good even roar, not lugging, but with the governor letting it work.

Graders

Graders can be used to remove snow from streets, parking lots, roads, runways, and taxiways to supplement the other snow removal equipment.

A grader is often used during clean-up operations after the major snow removal job has been accomplished. If slush is to be removed with a grader, many times the cutting edge is removed from the moldboard. A strip of hard rubber is bolted to the moldboard in place of the cutting edge. This prevents possible damage to the pavement surface, thus saving a great amount of maintenance work in the spring.

Loaders

In some congested areas, plows pile snow too high to see around at intersections, and the pile has to be removed. A wheeled loader is best-suited for this job.

Care must be taken when moving snow piles with a loader. Fireplugs, electrical and telephone boxes, and other utilities may be buried in the snow. If you are not sure what is under a pile of snow, ask your crew leader to check the base utilities plan before you attempt to move the pile.

Sand Spreader

Most snowplows are equipped with a sand spreader, commonly called a sander. Sand spreaders can be truck-mounted (fig. 14-42) or towed (fig. 14-43).

Spreading hot sand over ice with conventional sand spreading equipment (fig. 14-43) is considered to be one of the most effective ways of producing traction on iced surfaces. In this operation, the particles of hot sand embed themselves in the surface and thus resist removal by traffic and wind. For best results, the heated sand should be applied to the iced surface as quickly as possible.

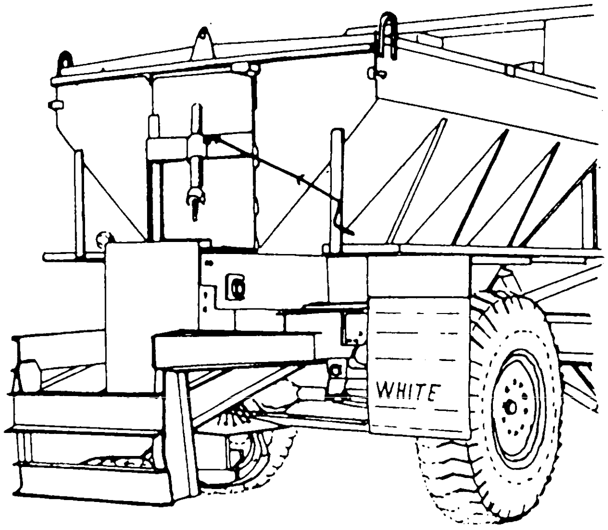


Figure 14-42.—Truck-mounted sand spreader.

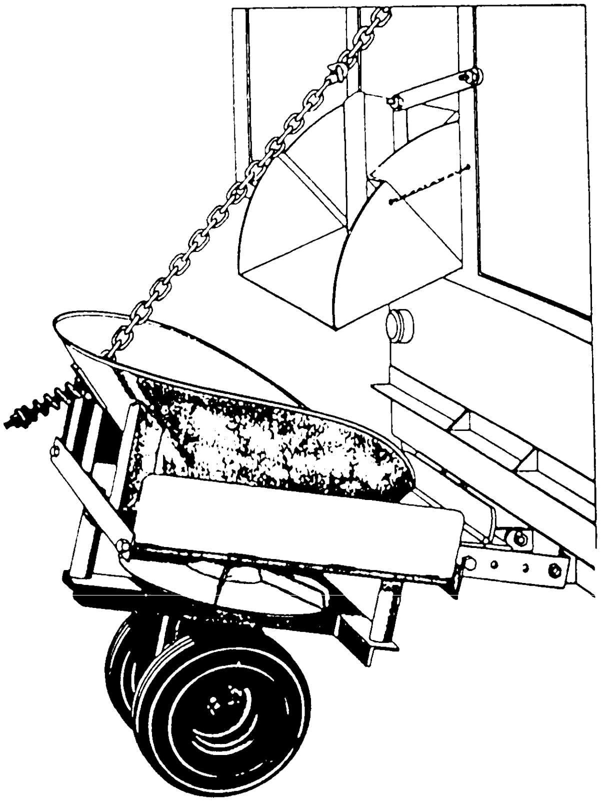


Figure 14-43.—Towed sand spreader.

Loose sand, applied with the sand spreader, is also used to produce traction on iced surfaces. This method is generally satisfactory, but because the sand is not firmly bonded to the ice, it is blown off the surface by wind and traffic. This method is more effective when applied to surfaces that are wet and when freezing temperatures are expected.

CHAPTER 15

EARTHWORK OPERATIONS

A solid foundation must be prepared to support roads, runways, buildings, and other temporary or permanent structures. To accomplish this task, the Naval Construction Force (NCF) must perform earthwork operations, often referred to as **horizontal construction.**

Earthwork operations include much more than just moving the earth. As an EO, you must be able to use the techniques required to achieve the finished product. You accomplish this by planning and developing the steps to complete the project, studying and understanding project drawings, computing earthwork volumes, reading and using construction grade stakes, transferring elevations with leveling equipment, and understanding the characteristics of soils and the procedures used in earthwork operations.

PROJECT PLANNING

In the NCF, the entire history of each construction project, from the initial planning phase, through the execution phase, to the closeout phase, is documented in a standard nine-folder project package (fig. 15-1). This format is used on all tasked projects.

NCF PROJECT PACKAGE

FILE #1 GENERAL INFORMATION FILE

LEFT Project Scope Sheet
Tasking Letter
Project Planning Checklist
Project Package Sign-off Sheet

RIGHT Project Organization
Deployment Calendar
Preconstruction Conference Notes
Predeployment Visit Summary

FILE #2 CORRESPONDENCE FILE

LEFT Outgoing Messages and Correspondence

RIGHT Incoming Messages and Correspondence

FILE #3 ACTIVITY FILE

LEFT Construction Activity Summary Sheets of Completed Activities

RIGHT Master Activity Sheets
Level 11
Level II Precedence Diagram
Master Activity Summary Sheets
Construction Activity Summary Sheets (Recommend including filled out 1250s and mineral products request)

Figure 15-1.—NCF project package outline.

FILE #4 NETWORK FILE

LEFT Computer Printouts
Level III
Level III Precedence Diagram

RIGHT Resource Leveled Plan for Manpower and Equipment
Equipment Requirement Summary

FILE #5 MATERIAL FILE

LEFT List of Long Lead Items
45 Day Material List
Material Transfer Request
Add On/Reorder Justification Forms
Bill of Materials/Matetial Takeoff Comparison Work Sheets
Material Takeoff Work Sheets

RIGHT Bill of Materials (including all add-on/Reorder BMs)

FILE #6 QUALITY CONTROL FILE

LEFT Various Quality Control Forms
Field Adjustment Request

RIGHT Daily Quality Control Inspection Reports
Quality Control Plan

FILE #7 SAFETY/ENVIRONMENT

LEFT Required Safety Equipment
Stand-up Safety Lectures
Safety Reports
Accident Reports

RIGHT Safety Plan
Highlighted EM 385
Environmental Plan (if applicable)

FILE #8 PLANS FILE

LEFT Site Layout
Shop Drawings
Detailed Slab Layout Drawings (if required)
Rebar Bending Schedule
Form Material Work Sheet

RIGHT Project Plans

FILE #9 SPECIFICATIONS FILE

LEFT Technical Data

RIGHT Highlighted Specifications

Figure 15-1.—NCF project package outline—Continued.

A flow chart, showing the sequence of planning steps, is shown in figure 15-2. These steps are also listed in the project planning milestones list (fig. 15-3). This list is normally assigned by the operations department at the beginning of home port. Step-by-step information on how a project package is developed is outlined in the *Naval Mobile Construction Battalion Crewleader's Handbook,* COMSECOND/COMTHIRDNCBINST 5200.2X.

PROJECT DRAWINGS

In the NCF, project drawings are normally divided into the following major categories: civil, architectural, structural, mechanical, and electrical.

Regardless of the category, project drawings serve the following functions:

- They provide a basis for estimating material, labor, and equipment before construction begins.
- They provide precise instructions for construction, showing the sizes and locations of various parts.
- They provide a means of coordination between the different ratings.
- They complement the specifications; one source of information is incomplete without the other.

Pages

Most drawings have sheets/pages with designator letters (I—Index, C—Civil, A—Architectural, S—Structural, M—Mechanical, P—Plumbing, E—Electrical, and W—Waterfront). For example, as shown in figure 15-4, the sheet designating letter and page number is the 22d architectural page in a set of plans, so it is written A-22. The name, or title, of the project will be in the largest block on the page. For EO

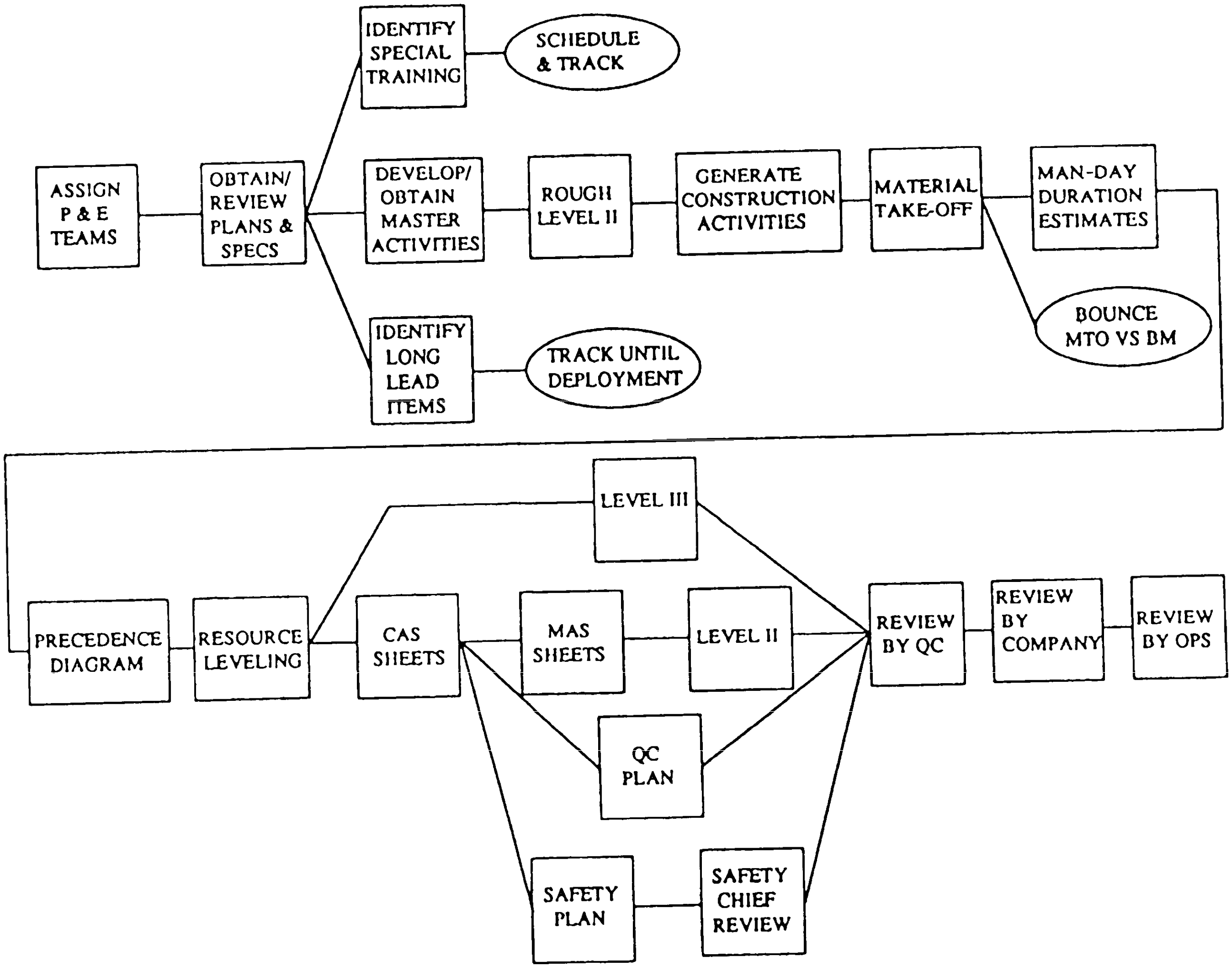

IDENTIFY SPECIAL TRAINING
SCHEDULE & TRACK
ASSIGN P & E TEAMS
OBTAIN/ REVIEW PLANS & SPECS
DEVELOP/ OBTAIN MASTER ACTIVITIES
ROUGH LEVEL II
GENERATE CONSTRUCTION ACTIVITIES
MATERIAL TAKE-OFF
MAN-DAY DURATION ESTIMATES
BOUNCE MTO VS BM
IDENTIFY LONG LEAD ITEMS
TRACK UNTIL DEPLOYMENT
LEVEL III
PRECEDENCE DIAGRAM
RESOURCE LEVELING
CAS SHEETS
MAS SHEETS
LEVEL II
REVIEW BY QC
REVIEW BY COMPANY
REVIEW BY OPS
QC PLAN
SAFETY PLAN
SAFETY CHIEF REVIEW

Figure 15-2.—Project planning flow chart.

PROJECT PLANNING MILESTONES

PROJECT ______________________________

	MILESTONE	DATE REQUIRED	DATE COMPLETED
1.	Designate Crew leader and Planning Team		
2.	Preplanning Conference		
3.	Review Plans and Specifications		
4.	Identify Long Lead Materials		
5.	Identify Required Skills and Training		
6.	Complete Project Scope Sheet		
7.	Complete Master Activity Listing		
8.	Develop Level II Network		
9.	Generate Construction Activity Listing		
10.	Develop Independent Material Takeoff		
11.	Develop BM/MTO Discrepancy List		
12.	Calculate Man-days and Durations		
13.	Complete Construction Activity Summary Sheets		
14.	Develop Level III Network		
15.	Input Network into Computer		
16.	Resource Level Project		
17.	Complete Master Activity Summary Sheets		
18.	Develop Level II Bar Chart		
19.	Consolidate Tool Requirements		
20.	Consolidate Equipment Requirements		
21.	Consolidate Safety Plan		
22.	Consolidate Quality Control Plan		
23.	Prepare Project Briefing		

Figure 15-3.—Project planning milestones.

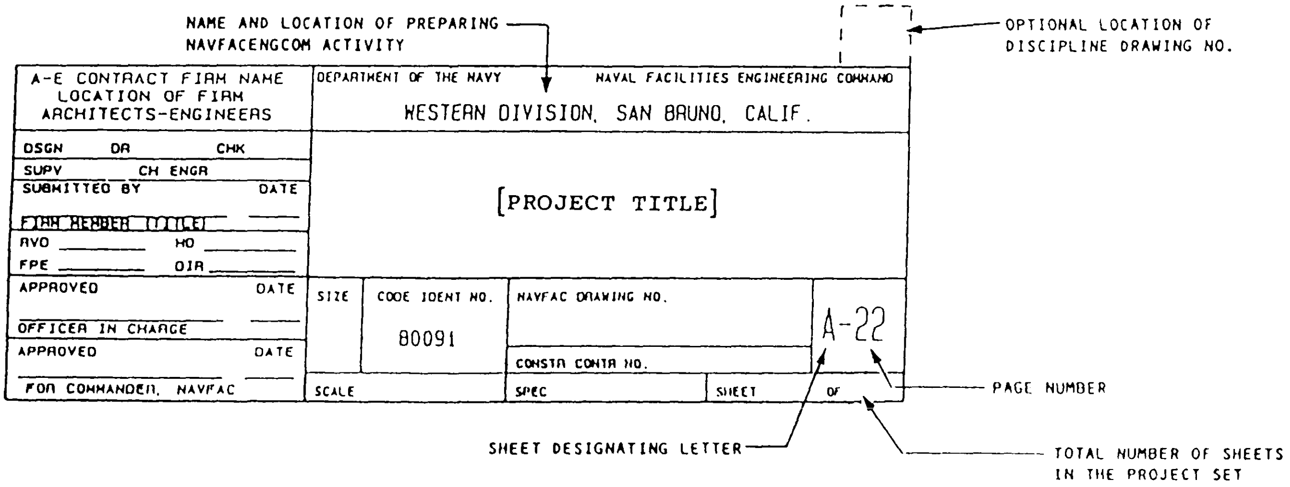

NAME AND LOCATION OF PREPARING NAVFACENGCOM ACTIVITY
OPTIONAL LOCATION OF DISCIPLINE DRAWING NO.
A-E CONTRACT FIRM NAME
LOCATION OF FIRM
ARCHITECTS-ENGINEERS
DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
WESTERN DIVISION, SAN BRUNO, CALIF.
DSGN
DR
CHK
SUPV
CH ENGR
SUBMITTED BY
DATE
FIRM MEMBER (TITLE)
RVO
MO
FPE
DIR
APPROVED
DATE
OFFICER IN CHARGE
APPROVED
DATE
FOR COMMANDER, NAVFAC
[PROJECT TITLE]
SIZE
CODE IDENT NO.
80091
NAVFAC DRAWING NO.
CONSTR CONTR NO.
A-22
SCALE
SPEC
SHEET
OF
PAGE NUMBER
SHEET DESIGNATING LETTER
TOTAL NUMBER OF SHEETS IN THE PROJECT SET

Figure 15-4.—Title block for drawings.

work, you should concentrate on the index and civil pages.

INDEX PAGE.— This page tells you where the project is located, what is in the set of drawings, and any special surveys that have been done.

CIVIL PAGES.—Civil pages encompass a variety of plans and information to include the following:

- Site preparation and site development
- Fencing
- Rigid and flexible pavements for roads and walkways
- Environmental pollution control
- Water supply units

Depending on the size of the construction project, the number of sheets/pages in a set of civil drawings may vary from a bare minimum to several sheets/pages of related drawings. Normally, on an average-size project, the first sheet/page has a location map, soil boring log, legends, and sometimes site plans and small civil detail drawings. (Soil boring tests are conducted to determine the water table of the construction site and classify the existing soil.)

A **site plan** (fig. 15-5) furnishes the essential data for laying out the proposed building lines. It shows the

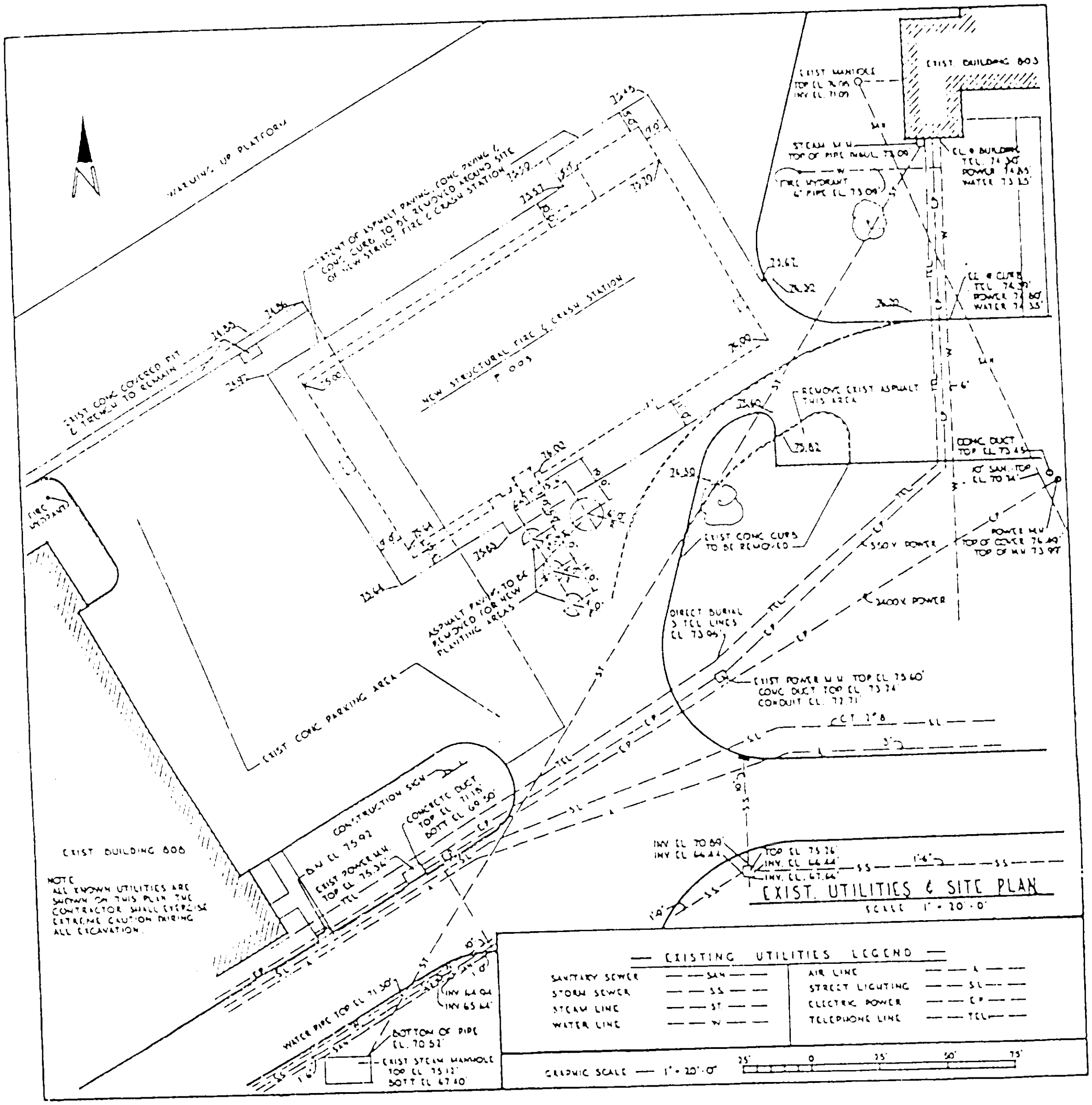

N
NEW STRUCTURAL FIRE & CRASH STATION
EXIST CONC PARKING AREA
EXIST BUILDING 606
EXIST BUILDING 605
NOTE
ALL KNOWN UTILITIES ARE SHOWN ON THIS PLAN. THE CONTRACTOR SHALL EXERCISE EXTREME CAUTION DURING ALL EXCAVATION.
INV EL 70.69
INV EL 66.44
TOP EL 75.26
INV. EL 66.44
INV. EL. 67.66
EXIST. UTILITIES & SITE PLAN
SCALE 1" = 20'-0"
— EXISTING UTILITIES LEGEND —
SANITARY SEWER — — SAN — —
STORM SEWER — — SS — —
STEAM LINE — — ST — —
WATER LINE — — W — —
AIR LINE — — A — —
STREET LIGHTING — — SL — —
ELECTRIC POWER — — EP — —
TELEPHONE LINE — — TEL — —
GRAPHIC SCALE — 1" = 20'-0"
25' 0 25' 50' 75'

Figure 15-5.—Example of a site plan with existing utilities.

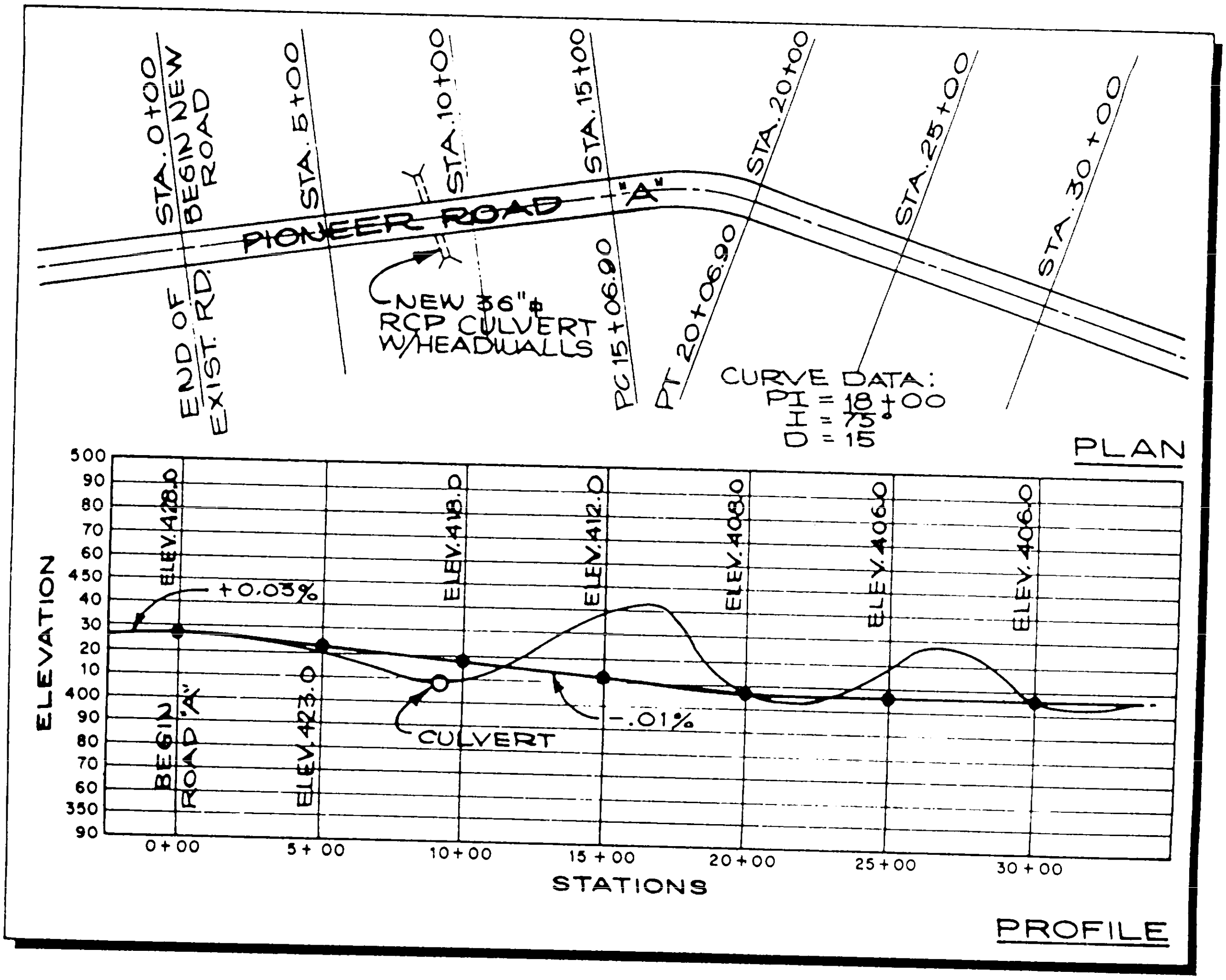

STA. 0+00
BEGIN NEW ROAD
END OF EXIST. RD.
STA. 5+00
STA. 10+00
STA. 15+00
STA. 20+00
STA. 25+00
STA. 30+00
PIONEER ROAD "A"
NEW 36"ϕ RCP CULVERT W/HEADWALLS
PC 15+06.90
PT 20+06.90
CURVE DATA:
PI = 18+00
I = 75°
D = 15
PLAN
500
90
80
70
60
450
40
30
20
10
400
90
80
70
60
350
90
ELEVATION
ELEV. 428.0
+0.03%
BEGIN ROAD 'A'
ELEV. 423.0
ELEV. 418.0
CULVERT
ELEV. 412.0
-.01%
ELEV. 408.0
ELEV. 406.0
ELEV. 406.0
0+00
5+00
10+00
15+00
20+00
25+00
30+00
STATIONS
PROFILE

Figure 15-6.—Plan and profile sheet.

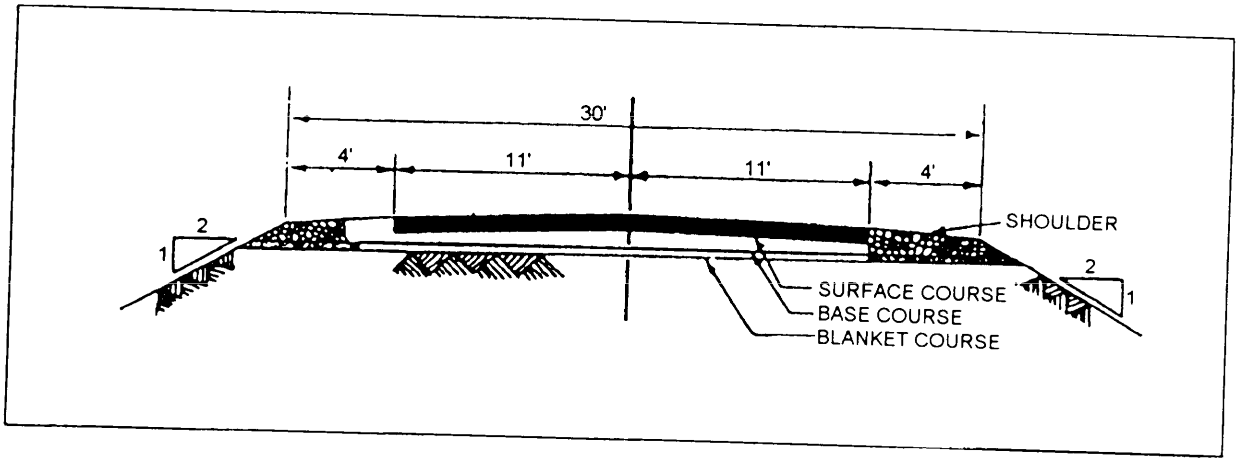

30'
4'
11'
11'
4'
2
1
2
1
SHOULDER
SURFACE COURSE
BASE COURSE
BLANKET COURSE

Figure 15-7.—Typical cross section.

contours, boundaries, roads, utilities, trees, structures, references, and other significant physical features on or near the construction site.

A plan and profile sheet (fig. 15-6) and a typical cross section (fig. 15-7) are other information found on a site plan.

Symbols

Symbols used in drawings are as follows:

- A **contour line** shows us an imaginary line, representing a constant elevation on the earth's surface. Blueprints, or plans, use contour lines to show the final proposed elevations.
- **Existing contour** lines identify the existing elevations (fig. 15-8). Existing and proposed elevations are used to figure cut-and-fill operations.
- **Proposed contour** lines are those we work toward, You use them to visualize the finished product (fig. 15-8).
- **Utility** symbols identify utility lines. The symbols for pipe are shown in figure 15-9. Once all the

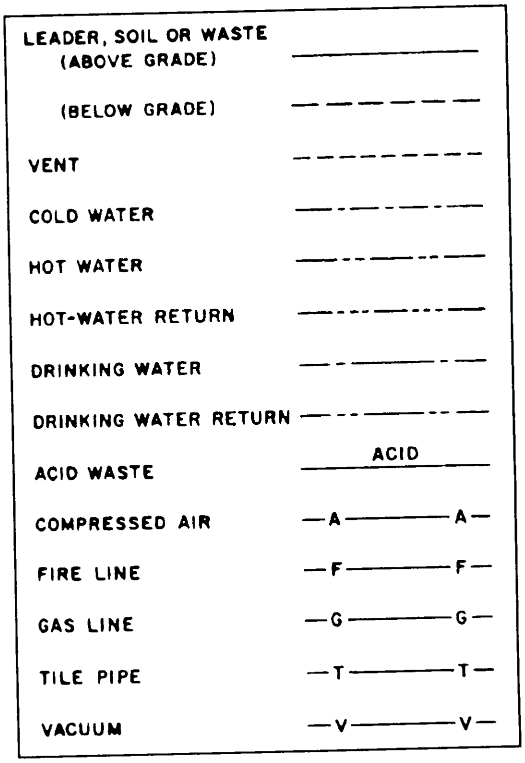

LEADER, SOIL OR WASTE
(ABOVE GRADE)
(BELOW GRADE)
VENT
COLD WATER
HOT WATER
HOT-WATER RETURN
DRINKING WATER
DRINKING WATER RETURN
ACID WASTE
ACID
COMPRESSED AIR
A A
FIRE LINE
F F
GAS LINE
G G
TILE PIPE
T T
VACUUM
V V

Figure 15-9.—Utility symbols for piping.

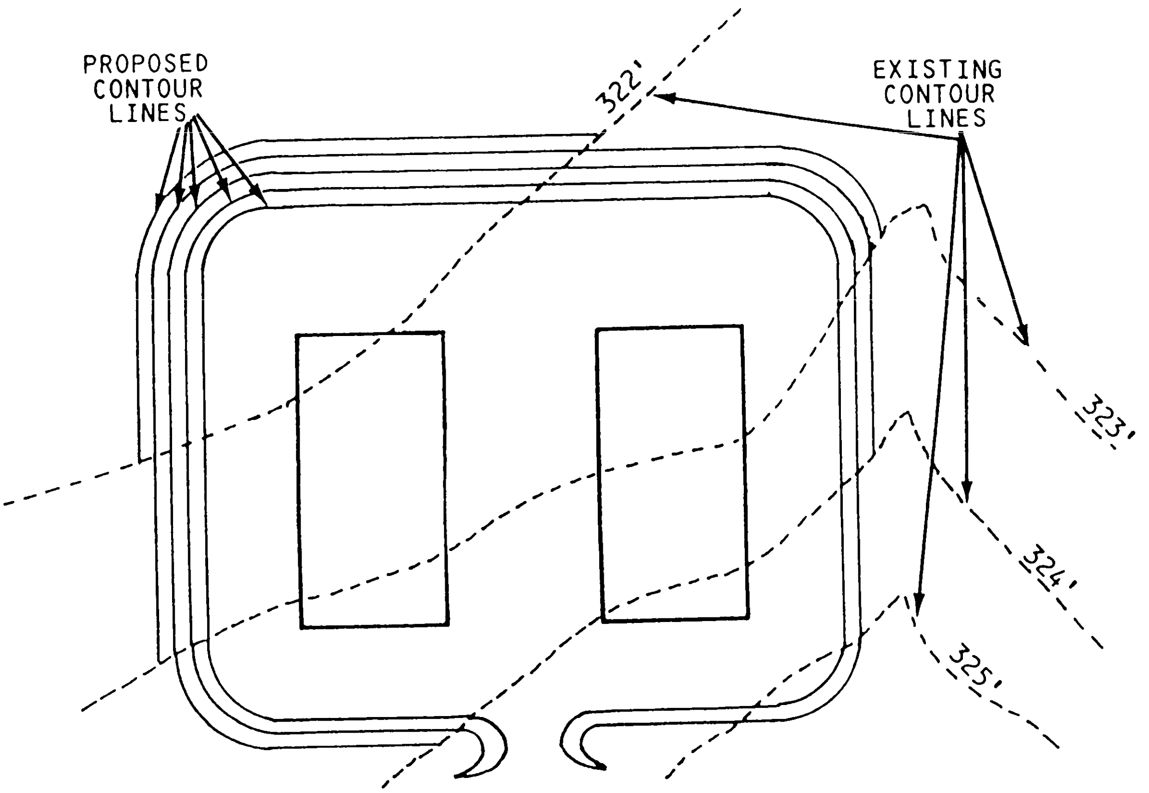

PROPOSED CONTOUR LINES
EXISTING CONTOUR LINES
322'
323'
324'
325'

Figure 15-8.—Existing and proposed contour lines.

existing underground utilities are identified, use extreme care when working near them. Ripping up utility lines adds loss time to a project, adds to the cost of the project, and causes an inconvenience to people to whom the utilities were supporting.

NOTE: Obtain a digging permit before performing any excavations on a project.

Symbols for electric power distribution are shown in figure 15-10. Note the location of these lines not only for the reasons stated about pipe but also because of the risk of electric shock when a machine cuts an electric line.

NOTE: On some occasions certain items are mistakenly left out on new drawings. Examples are buried telephone cables, electrical lines, waterlines, and fuel lines. Because of this, you must make it a practice to compare older drawings with new drawings and to your freehand sketches.

Symbols for building material are shown in figure 15-11. These symbols are used in cross sections or cutaway views. They also label material as **new** or **existing.**

Sketches

A **freehand sketch** is a drawing, made without the use of mechanical aids or devices. Sketches may be drawn on graph paper, traced, or drawn with a straightedge. A sketch may be of an object, an idea, or a combination of both. The ability to make quick, accurate sketches is helpful in conveying your ideas to others.

Two examples of freehand sketches are shown in figures 15-12 and 15-13. These sketches were

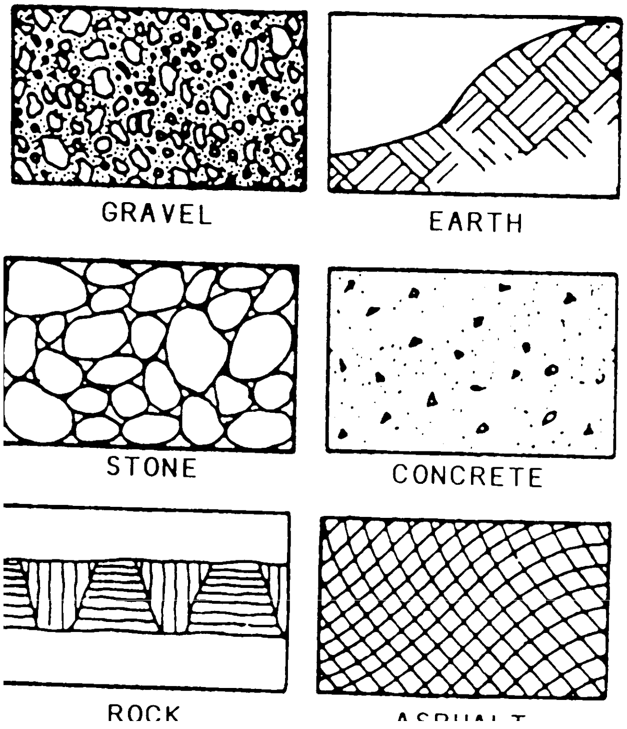

GRAVEL
EARTH
STONE
CONCRETE
ROCK
ASPHALT

Figure 15-11.—Material symbols.

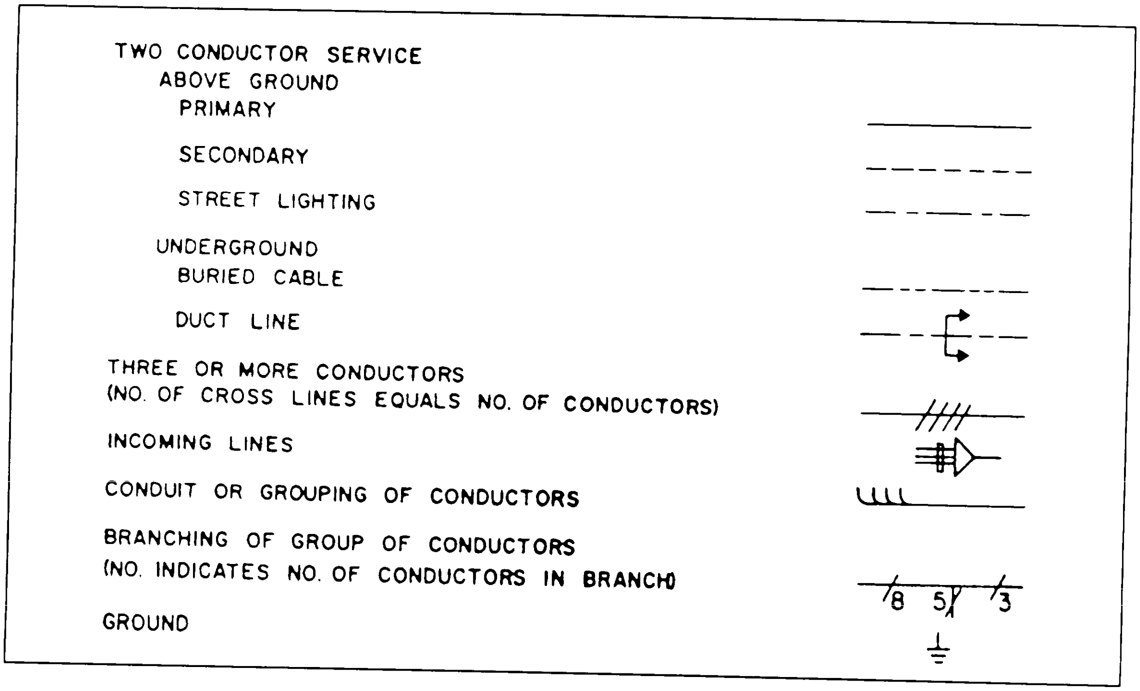

TWO CONDUCTOR SERVICE
ABOVE GROUND
PRIMARY
SECONDARY
STREET LIGHTING
UNDERGROUND
BURIED CABLE
DUCT LINE
THREE OR MORE CONDUCTORS
(NO. OF CROSS LINES EQUALS NO. OF CONDUCTORS)
INCOMING LINES
CONDUIT OR GROUPING OF CONDUCTORS
BRANCHING OF GROUP OF CONDUCTORS
(NO. INDICATES NO. OF CONDUCTORS IN BRANCH)
GROUND
8
5
3

Figure 15-10.—Electrical power distribution symbols.

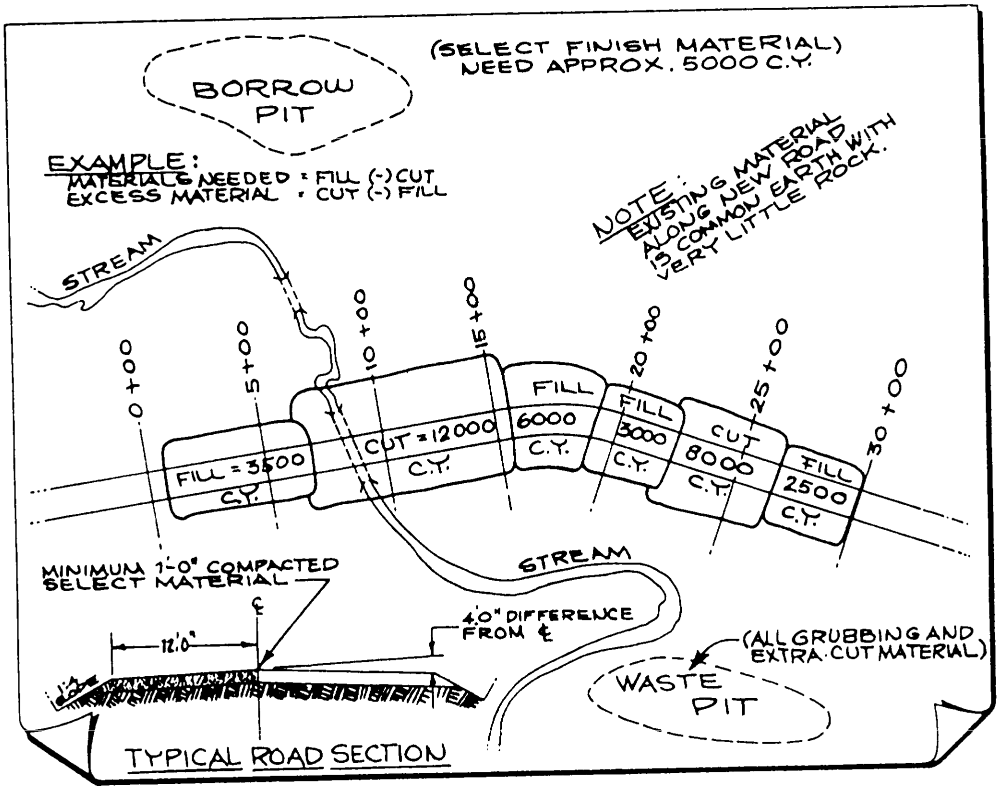

BORROW PIT
(SELECT FINISH MATERIAL)
NEED APPROX. 5000 C.Y.
EXAMPLE:
MATERIALS NEEDED = FILL (-) CUT
EXCESS MATERIAL = CUT (-) FILL
NOTE: EXISTING MATERIAL ALONG NEW ROAD IS COMMON EARTH WITH VERY LITTLE ROCK.
STREAM
0+00
5+00
10+00
15+00
20+00
25+00
30+00
FILL = 3500 C.Y.
CUT = 12000 C.Y.
FILL 6000 C.Y.
FILL 3000 C.Y.
CUT 8000 C.Y.
FILL 2500 C.Y.
STREAM
MINIMUM 1'-0" COMPACTED SELECT MATERIAL
℄
12'0"
4'0" DIFFERENCE FROM ℄
(ALL GRUBBING AND EXTRA CUT MATERIAL)
WASTE PIT
TYPICAL ROAD SECTION

Figure 15-12.—Overlay plan sketch, emphasizing cut-and-fill areas.

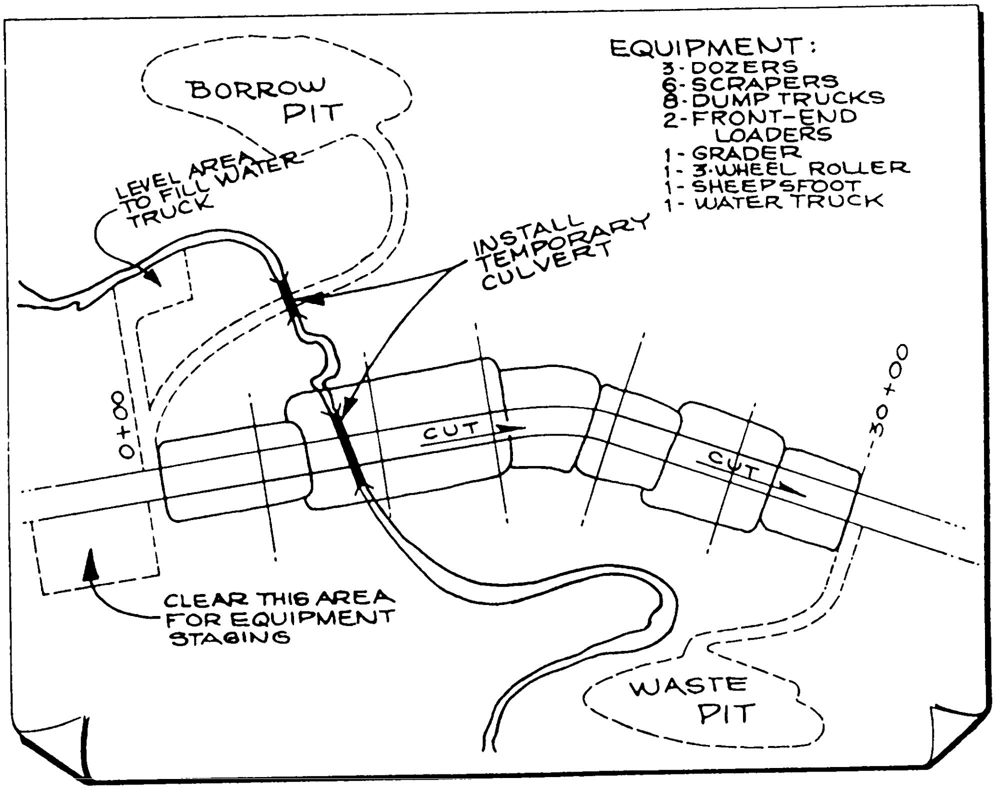

BORROW PIT
EQUIPMENT:
3-DOZERS
6-SCRAPERS
8-DUMP TRUCKS
2-FRONT-END LOADERS
1-GRADER
1-3-WHEEL ROLLER
1-SHEEPSFOOT
1-WATER TRUCK
LEVEL AREA TO FILL WATER TRUCK
INSTALL TEMPORARY CULVERT
0+00
CUT
CUT
30+00
CLEAR THIS AREA FOR EQUIPMENT STAGING
WASTE PIT

Figure 15-13.—Overlay sketch, emphasizing temporary road and culvert.

developed from the original plan and profile sheet of a typical road project. They depict different earthwork phases to be considered by the EO when engaged in earthmoving operations.

The sketches shown in figures 15-12 and 15-13 were prepared by placing a piece of tracing paper directly over the plan and profile sheet and tracing the new road and stations. Information was added that was not included on the original plan and profile sheet, such as borrow pit, waste pit, stream, temporary haul road, temporary culverts, equipment area, planned cut-and-fill areas, and a typical road section. Any information may be included that allows you to visualize the finished product.

EARTHWORK COMPUTATIONS

Earthwork computations are the calculations of earthwork volumes or quantities to determine final grades, to balance cut and fill, and to **PLAN** the most economical movement of material.

Volume Changes

Most earthmoving is computed in cubic yards; however, on some project drawings, the metric system is used. A cubic yard is a cube 3 feet long, 3 feet wide, and 3 feet high. Many dimensions in field measurements and contract plans are in feet, so if they are multiplied together to obtain bulk (length x width x depth), the results are in cubic feet. To obtain cubic yards from cubic feet, divide the cubic feet by 27 (there are 27 cubic feet in one cubic yard). It is also possible to divide the original linear measurement by 3 to convert the numbers to into yards, and then multiply. However, this may lead to working in fractions, decimals, and mixed numbers.

Cubic yards of material are either **in place, loose,** or **compacted.** Material, excavated from its natural state, increases in volume, commonly known as **swell.** Undisturbed material is measured as **in-place cubic yards,** material loosen by handling is measured in **loose cubic yards,** and the volume of compacted material is measured as **compacted cubic yards.**

NOTE: When calculating estimates from project drawings, you estimate **cuts as in-place cubic yards** and estimate **fills as compacted cubic yards.**

To calculate the correct amount of material to be handled, you convert the present soil conditions by using table 15-1.

Road Nomenclature

A cross-sectional view of a road and its components is shown in figure 15-14. Before any construction is performed on a project site, the elevation is known as **existing grade.** The driving

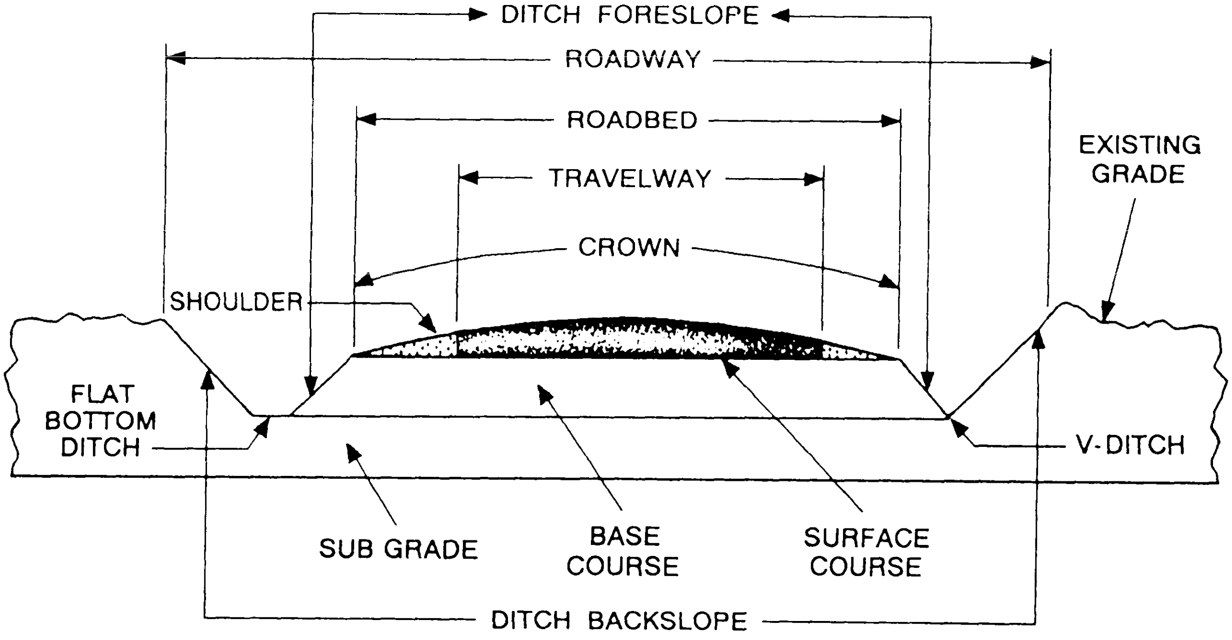
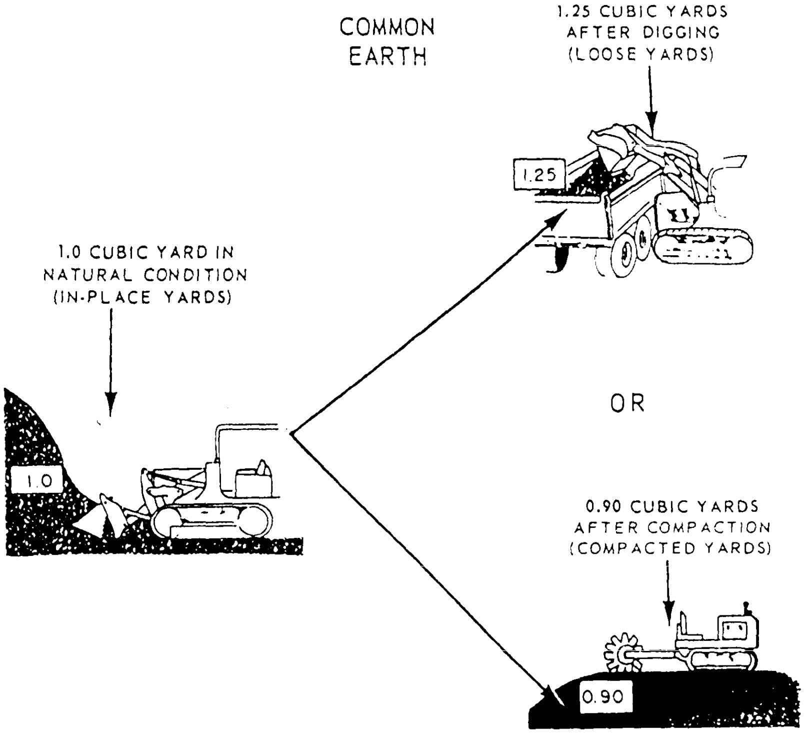


Figure 15-14.—Road nomenclature.

surface of an existing road that is to be replaced is also known as the **existing grade.** The **subgrade** of a road is a prepared base for the placement of base-course materials. The **base course** is a select layer of well-compacted soil that is placed in compacted lifts on top of the subgrade. This compaction can be accomplished by mechanical stabilization or chemical stabilization. The **surface course** and the **shoulders** complete the road. The surface course is usually concrete or asphalt and is part of the road that vehicles travel on. The shoulder of the road performs as a retainer on each side of the surface course and provides an emergency parking area.

The **crown** of the road is an established slope from the center line of a roadbed to the outside of the shoulders and allows for excess water to drain from the surface into either a **V type** or **flat bottom type of ditch.** The area that covers the entire width of the road

Table 15-1.—Volume Changes


COMMON EARTH
1.25 CUBIC YARDS AFTER DIGGING (LOOSE YARDS)
1.25
1.0 CUBIC YARD IN NATURAL CONDITION (IN-PLACE YARDS)
1.0
OR
0.90 CUBIC YARDS AFTER COMPACTION (COMPACTED YARDS)
0.90

SOIL TYPE	PRESENT SOIL CONDITION	CONVERTED TO:		
		INPLACE	LOOSE	COMPACTED
SAND	INPLACE	1.00	1.11	0.95
	LOOSE	0.90	1.00	0.86
	COMPACTED	1.05	1.17	1.00
COMMON EARTH	INPLACE	1.00	1.25	0.90
	LOOSE	0.80	1.00	0.72
	COMPACTED	1.11	1.39	1.00
CLAY	INPLACE	1.00	1.43	0.90
	LOOSE	0.70	1.00	0.63
	COMPACTED	1.11	1.59	1.00
ROCK	INPLACE	1.00	1.30-2.00	1.25-1.50
	LOOSE	0.50-0.77	1.00	0.75-0.96
	COMPACTED	0.67-0.80	1.04-1.33	1.00

project, including the ditches, is known as the **roadway.** The **roadbed** is the section that includes the surface course and both shoulders, and the **travel way** is the surface course that the vehicle travels on.

Slope Ratio

The two most common slopes used in road construction are the **foreslope** and **backslope.** The foreslope extends from the outside of the shoulder to the bottom of the ditch. The backslope extends from the top of the cut at the existing grade to the bottom of the ditch. The amount of slope in a foreslope or backslope is the ratio of horizontal distance to vertical distance (fig. 15-15). That means that for every one (1) foot of vertical (up or down), the horizontal distance changes proportionally. The following are equations to compute slope ratio:

1. If the base and the height are known factors, but not the slope, use the following:

Base ÷ Height = Slope

(B + H = S

2. If the slope ratio and the height are known factors, but not the base, use the following:

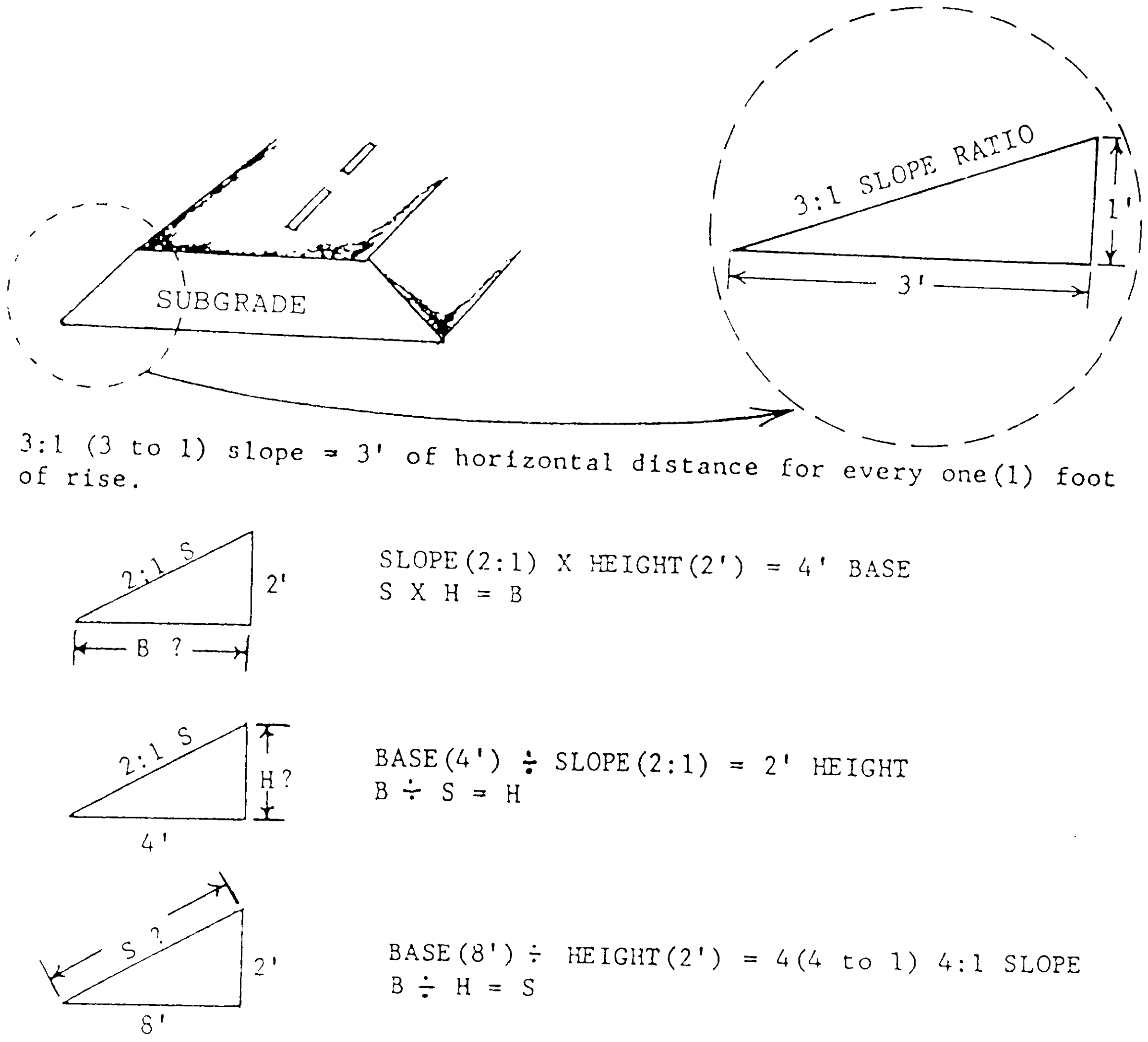
Slope x *Height = Base*

(S x *H = B)*

3. If the base and the slope ratio are known factors, but not the height, use the following:

Base ÷ Slope = Height

(B ÷ S = H)



3:1 (3 to 1) slope = 3' of horizontal distance for every one(1) foot of rise.

SLOPE(2:1) X HEIGHT(2') = 4' BASE
S X H = B

BASE(4') ÷ SLOPE(2:1) = 2' HEIGHT
B ÷ S = H

BASE(8') ÷ HEIGHT(2') = 4(4 to 1) 4:1 SLOPE
B ÷ H = S

Figure 15-15.—Slope ratio.

Cross Sections

A **cross-sectional view** (fig. 15-16) that is given for a road project is a cutaway end view of a proposed station between the left slope and the right slope. Typical cross sections are plotted at any intermediate place where there is a distance change in slope along the center line where the natural ground profile and grade line correspond. The cross section displays the slope limits, the slope ratio, and the horizontal distance between centerline stakes and shoulder stakes. It also shows the vertical distance of the proposed cut or fill at the shoulder and centerline stakes.

To compute the area of a cross section, you must first break it down into geometric figures (squares, triangles, etc.). (See fig. 15-17.) Compute each area separately, then total the results to obtain the total **square feet.**

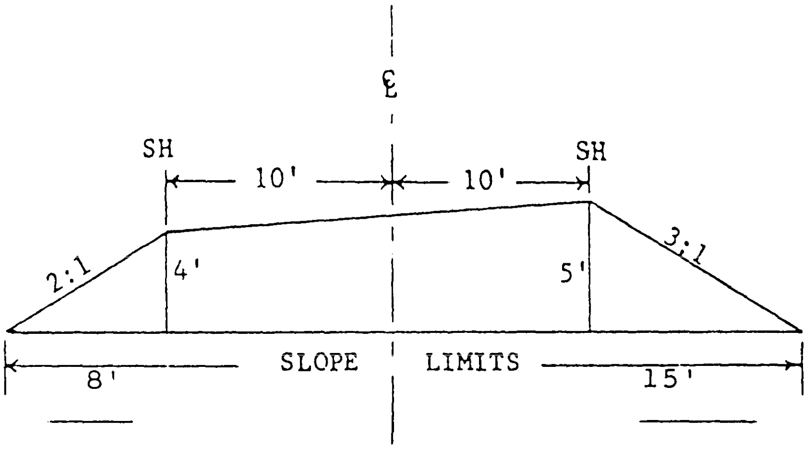


Figure 15-16.—Cross section.

TO COMPUTE THE AREA OF A CROSS SECTION, FIRST BREAK IT DOWN INTO GEOMETRIC FIGURES (SQUARES, TRIANGLES, ETC.); THEN COMPUTE EACH AREA SEPARATELY AND TOTAL THE RESULTS.

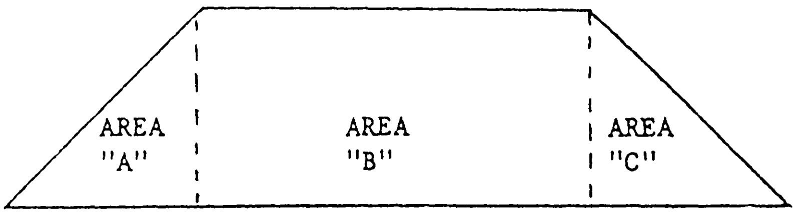


Figure 15-17.—geometric sections of a cross section.

To compute the square feet area of a SQUARE or RECTANGLE (fig. 15-18), use the following equation:

Area = Base x *Height* or *(A = B x H).*

Since a RIGHT TRIANGLE is a square or rectangle cut in half diagonally, the same equation can be used to compute the area and the result divided by 2 (fig. 15-19). For example,

$$\text{Triangle area in square feet} = \frac{\text{Base} \times \text{Height}}{2}$$

or $B \times H + 2$ = Triangle area in square feet

Another geometric figure you may encounter in a cross section is a TRAPEZOID (fig. 15-20). The equation to compute the area of a trapezoid is as follows:

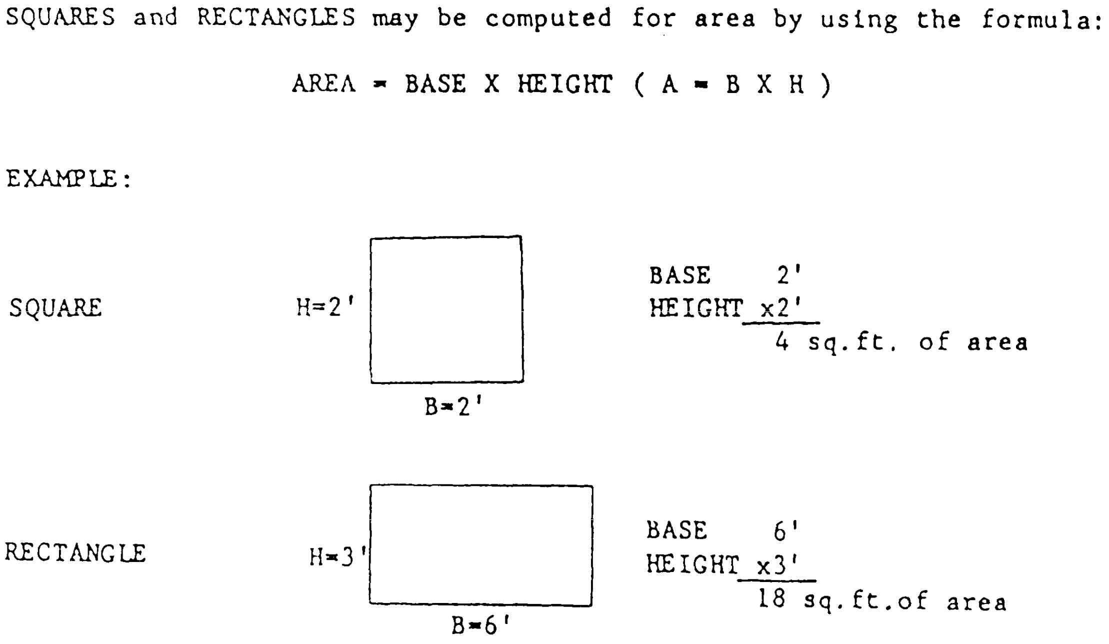
$$\text{Trapezoid Area in square feet} = \left(\frac{H_1 + H_2}{2}\right) \times L$$

or H_1 = Height of one side

+ H_2 = Height of other side

Sum + 2 × *Length* = Trapezoid area in square feet.

The next step is to compute the total area in the cross section (fig. 15-21). This is accomplished by adding the results of each geometric figure in the cross



SQUARES and RECTANGLES may be computed for area by using the formula:

AREA = BASE X HEIGHT (A = B X H)

EXAMPLE:

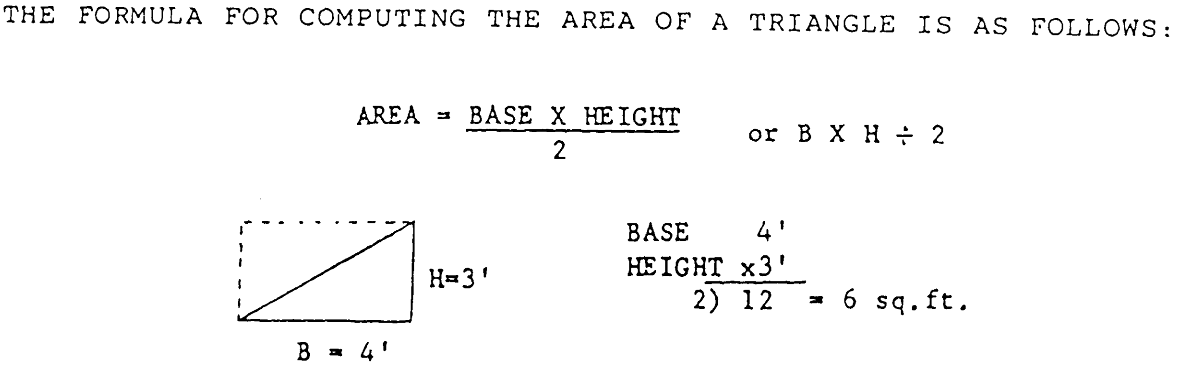
SQUARE

BASE 2'
HEIGHT x2'
4 sq.ft. of area

RECTANGLE

BASE 6'
HEIGHT x3'
18 sq.ft.of area

Figure 15-18.—Area of a square and rectangle.



THE FORMULA FOR COMPUTING THE AREA OF A TRIANGLE IS AS FOLLOWS:

AREA = $\frac{\text{BASE X HEIGHT}}{2}$ or B X H ÷ 2

BASE 4'
HEIGHT x3'
2) 12 = 6 sq.ft.

Figure 15-19.—Area of a triangle.

section. This value is the total end area of the cross-sectional view.

To compute the amount of cubic yards between two cross sections, use the following equation:

$(A_1 + A_2)$ x 1.85 x *Distance*= *Cubic yards*

A_1 = Area of one end cross section

A_2 = Area of other end of cross section

1.85 = Constant factor

D = Distance between two end areas that must be changed to a decimal form; for example, 250 feet = 2.50, 125 feet= 1.25,75 feet= .75, and so forth

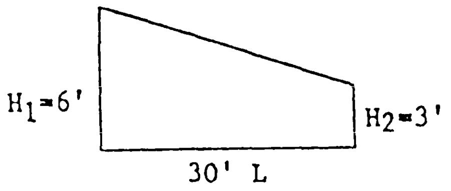
To compute the equation, take the area of one end section (cross section) plus the area of the other end and multiply the sum of the two areas by a constant factor of 1.85. This value should now be multiplied by the distance between the two end areas to determine the number of cubic yards. (See fig. 15-21.)

CONSTRUCTION (GRADE) STAKES

Grade work is the plotting of irregularities of the ground (making cuts or fills) to a definite limit of grade (elevation) and alignment. This is performed by reading information placed on construction (grade) stakes.

THE FORMULA FOR COMPUTING THE AREA OF A TRAPEZOID IS AS FOLLOWS:

$$\text{AREA} = \frac{H_1 + H_2 \times L}{2}$$



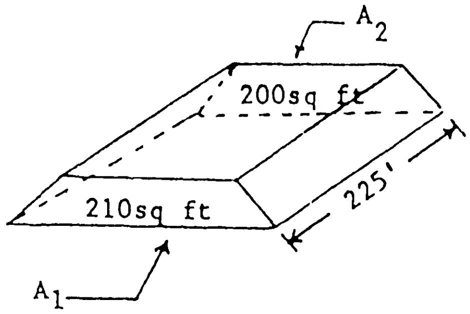
H^1 = 6'

H^2 = +3'

2) 9 = 4.5 x 30' = 135.0 sq.ft.

Figure 15-20.—Area of trapezoid.

THE FORMULA FOR COMPUTING CUBIC YARDS IS AS FOLLOWS:
$(A_1 + A_2)$ 1.85 x DISTANCE = CUBIC YARDS



A_1 = 210 sq ft

A_2 = +200 sq ft

410

x1.85 FACTOR

2050

3280

410

758.50

x2.25 DISTANCE

379250

151700

151700

1706.62$\cancel{5}$0

1706.63 CUBIC YARDS

Figure 15-21.—Computing cubic yards of cross sections.

Construction stakes, sometimes referred to as **grade stakes,** are the guides and reference markers for earthwork operations to show cuts, fills, drainage, alignment, and boundaries of the construction area. The number of stakes and the information contained on them will vary with the project as to whether they are temporary or permanent. Stakes are usually placed by a three- to five-person survey party using a level, a level rod, a tape, and range poles.

A **"stake"** is defined as any wooden lath, stake, or hub. **"Hub stakes"** are 2 inches by 2 inches by approximately 12 inches and are used primarily for well-defined surveyors' reference points, with the red and blue tops used in finished grade work. Stakes will vary in shape and size according to their use and the materials available for their manufacture. Several stakes are shown in figure 15-22. Stakes range in size from the ordinary rough plaster lath to 1- by 2- by 3-inch cross-sectional lumber with lengths varying from 18 inches to 48 inches.

All reference hubs, markers, and bench marks established by the Engineering Aids (EAs) for project control or alignment are protected by **guard stakes. Guard stakes** are used as a means of locating the points needed. Some color of bunting or flagging (a narrow strip of cloth or plastic) may be tied around the top of the stake. Station identification is placed on the front of the stake and any other pertinent data on the back.

In some situations, the survey crew will establish grades only on the centerline stakes, while edge-of-road and slope stakes are set by the project supervisor and helpers. Alignment, shoulder, and slope stakes should be 1 inch by 2 inches in cross section, smooth on four sides, and about 2 feet in length. Actual grade desired is indicated by a reference mark, called a crowfoot, and numbers to show the amount of cut or fill.

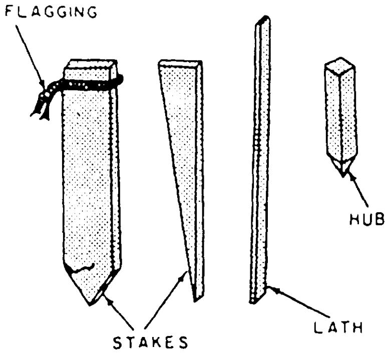


Figure 15-22.—Types of stakes.

These stakes should be marked with the following information:

- The stationing or location of any part of the road, runway, or taxiway relative to a starting point or reference
- The amount of cut and fill from the existing ground surface or reference mark on the stake
- The distance from the center line to the stake location and from the center line to the ditch line

In most earthwork, measurements are made and written by the decimal system as used in construction engineering. Most markings on construction stakes will be in feet and tenths of a foot. A stake marked $C3^5$ means that a cut must be made 3.5 feet. To convert .5 foot to inches, multiply the decimal fraction by 12. For example: .5 x 12 inches = 6 inches; .25 x 12 inches = 3 inches.

STARTING POINT

The **"starting point"** of a survey is also called the **starting station** and is numbered 0 + 00. The next station is 100 feet farther away and is numbered 1 + 00. The next station, which is 200 feet beyond the starting point, is then numbered 2 + 00, and so forth. All stations that end with 00 are called **full stations.** As shown in figure 15-23, stations may be abbreviated **STA** on the stakes.

On sharp curves or on rough ground, the stakes may be closer together than on the straightaway. Stations, located at a distance shorter than 100 feet from the preceding station, are known as **plus stations,** such as

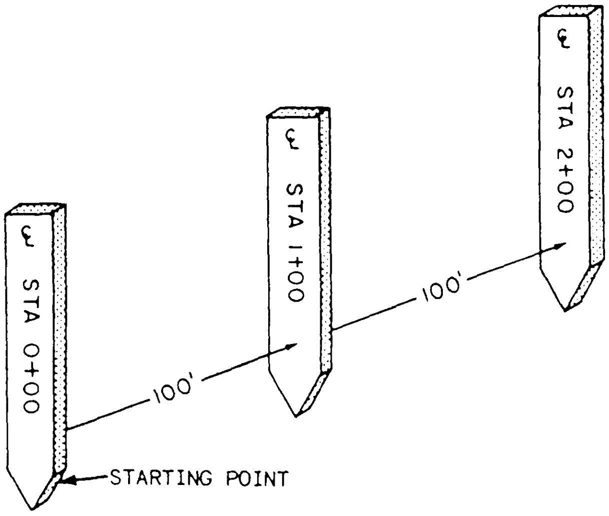


Figure 15-23.—Starting point.

3 + 25, 3 + 53, and 3 + 77. These examples are plus stations of station 3 + 00.

LINE STAKES

Line (or alignment) stakes mark the horizontal location of the earthwork to be completed and give the direction of the proposed construction. Running over stakes or otherwise damaging the stakes before they have served their purpose results in many hours of extra work to replace them and delay in the completion of the project. **Rough alignment stakes** are placed far ahead of the clearing crew to mark boundaries of the area to be cleared and grubbed. These stakes, or markers, are not of a control nature and their loss is expected. On some stakes, the alignment information and the grade requirement are combined on the same stake (fig. 15-24).

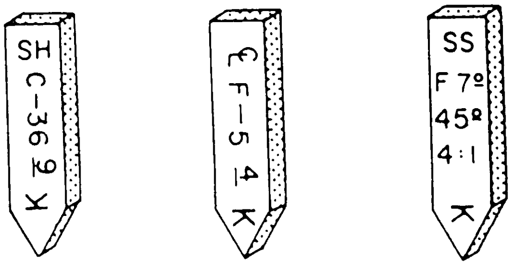


Figure 15-24.—Combined alignment and grade stake.

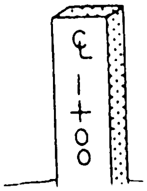


Figure 15-25.—Centerline stake

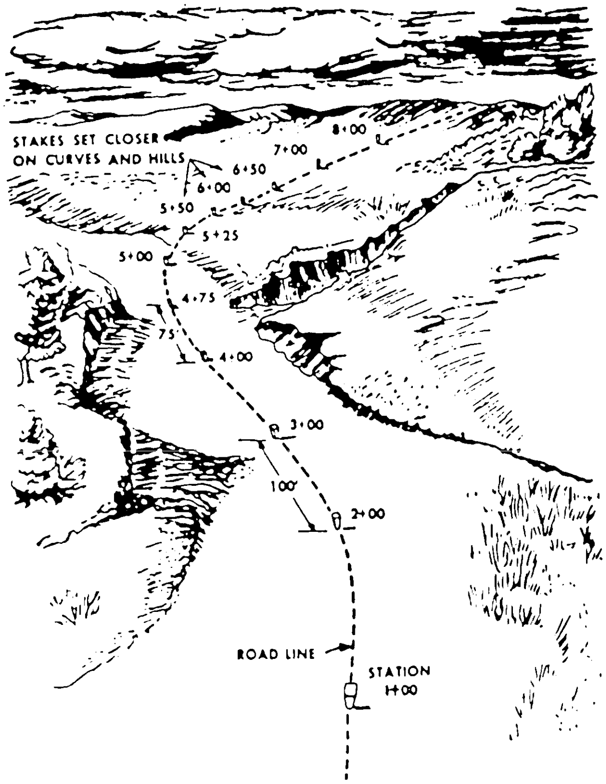


Figure 15-26.—Station numbers.

Centerline Stakes

Stakes set along the center line of a project are known as **centerline** stakes and are identified by letters, as shown in figure 15-25. Most stakes are marked on both the front and back.

On centerline stakes, the station number is written on the front of the stake, such as 0 + 00, 1 + 00, 4 + 75, and 5 + 25 (fig. 15-26).

The required grade is always established at the center line of the project. The amount of change in elevation is written on the back of the centerline stake with a **cut-** or- **fill** symbol, which is known as the crowfoot (fig. 15-27). The **"crowfoot"** is the reference point of the vertical measure or grade.

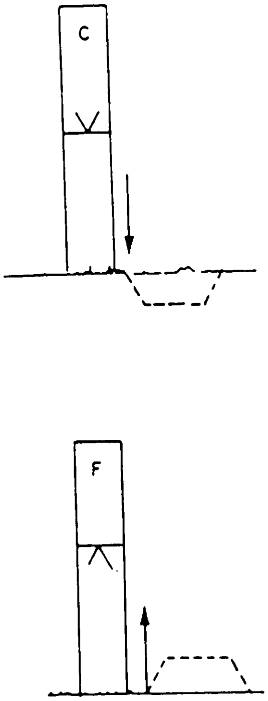


Figure 15-27.—Cut-and-fill crowfoot symbol.

Shoulder Stakes

Stakes that are set on a line parallel (same direction and interval) with the center line are called **shoulder stakes** and are identified by the symbol **SH** at the top of the stake (fig. 15-28).

Shoulder stakes mark the outer edge of the shoulders and are set with the broad side facing the center line of the road on the shoulder line. Shoulder stakes carry the same station number as the centerline stake they are set to, but the station number is placed on the **back of the stake** (the side facing away from the center line). The amount of cut or fill is marked on the side of the shoulder stake facing the center line (front) and represents the amount of cut or fill required at that location. The horizontal distance from the shoulder stake to the center line is sometimes placed beneath the cut-or-fill figure. The basic difference between centerline stakes marked with the ℄ symbol and shoulder stakes marked **SH** is (1) centerline stakes are set along the center line of the project and (2) shoulder stakes are set parallel with the center line defining the shoulder of the road or runway and face the center line (fig. 15-29).

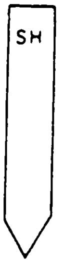


Figure 15-28.—Shoulder stake symbol.

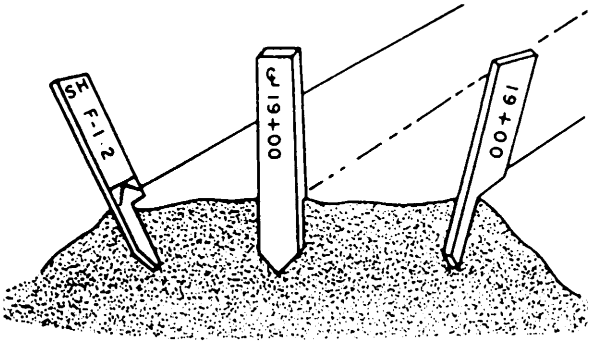


Figure 15-29.—Center line and shoulder stakes.

Cut-and-Fill Stakes

Lowering the elevation of a grade is known as making a **cut. Cut stakes** are designated by the letter **C** written on the stake. The numerals, following the letter **C,** indicate the amount of ground to be cut to obtain the desired grade and are measured from the crowfoot down.

Raising the elevation of the ground is known as making a **fill.** A **fill stake** is designated by the letter **F** written on the stake. The numerals that follow the letter **F** indicate the amount of ground material needed to bring the existing ground to the desired grade and are measured from the crowfoot mark on the stake up.

In going from a cut to a fill or vice versa, there may be one or more stakes representing points on the

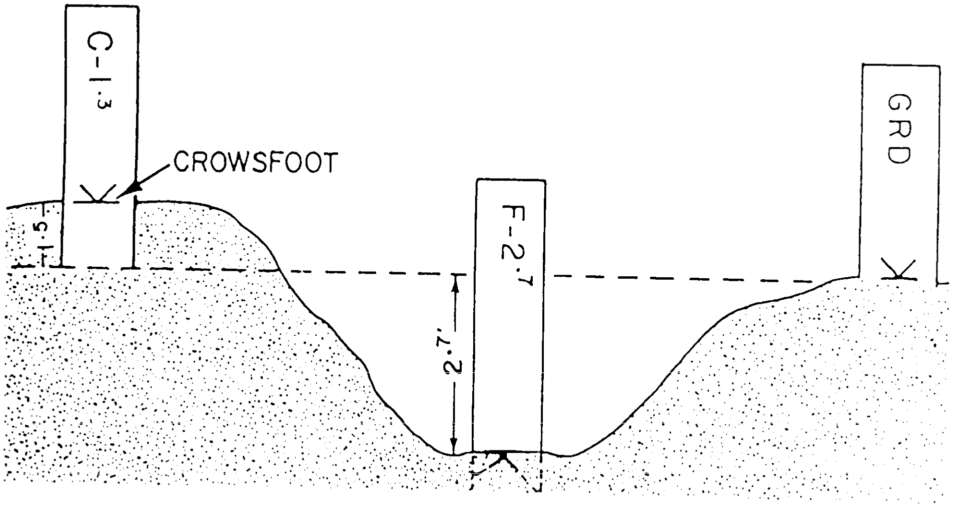


Figure 15-30.—Cut, fill, and on-grade stakes.

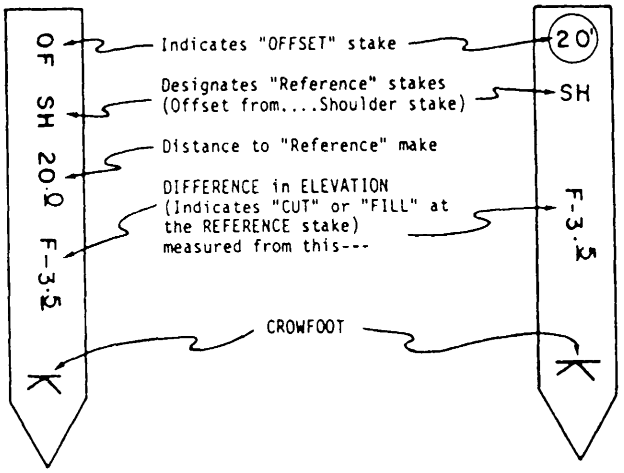
desired grade, as shown in figure 15-30. These stakes are marked with **GRADE,** or **GRD,** and a crowfoot mark even with the desired grade.

Basically, the difference in cut, fill, or on-grade stakes is as follows:

- Cut stakes indicate a lowering of the ground or elevation.
- Fill stakes indicate raising the ground or elevation.
- On-grade stakes indicate the ground is at the desired grade and does not need a cut or fill.

Offset Stakes

After a survey of a project has been completed and the stakes are set and marked, the required amount of work needed to complete the job is determined by using the information on these stakes. Since this information has to be used often during construction and the original stakes can be destroyed or covered up by carelessness or inexperienced operators, it is necessary to document this information.



OF SH 20.0 F-3.5
Indicates "OFFSET" stake
Designates "Reference" stakes (Offset from....Shoulder stake)
Distance to "Reference" make
DIFFERENCE in ELEVATION (Indicates "CUT" or "FILL" at the REFERENCE stake) measured from this---
CROWFOOT
20'
SH
F-3.5

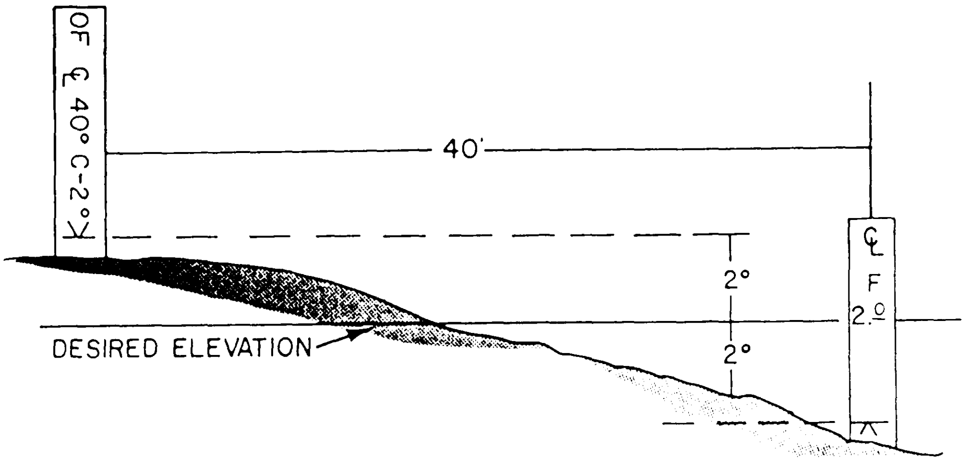
Figure 15-31.—Reference information found on a offset stake.

To prevent the loss of reference information, you should transfer the required information from the stake located in the immediate area of construction to a new stake. Set this stake far enough away so that it will not be damaged or destroyed by equipment being operated in the construction area. This new stake is called an **offset stake** and is identified by the symbol **OF** or an **O** (fig. 15-31).

You should note the number of linear feet that separates the offset stake from the original reference stake. This is written on the offset stake below the **OF** or within the circle, followed by the amount of cut or fill, in feet, which may be required. A stake marked “OF 35′CL C-1º” means that the stake is offset 35 feet from the centerline stake and that a cut of 1 foot is required to attain the desired final grade.

The difference in elevation must be noted on the offset stake. The symbol, representing the stake from which the information was originally transferred, is also noted on the offset stake. If the offset stake was offset from a shoulder stake, the symbol would be **SH** instead of ℄.

The amount of cut or fill, if any, must be noted on the offset stake. However, because of existing terrain, this information on the offset stake may not be the same as that on the original stake. In figure 15-32, you can see that the offset stake reads for a cut to be made to reach a desired elevation at the center line, while a



OF ℄ 40° C-2°
40'
2°
2°
DESIRED ELEVATION
℄
F
2.0

Figure 15-32.—Difference in elevation between the offset stake crowfoot and desired grade at center stake.

centerline stake would be marked for a fill to reach the same elevation.

Slope Stakes

The identification markings on slope stakes may vary according to survey parties; however, the symbol **SS** is the most commonly used slope stake symbol. The information normally found on a slope stake (fig. 15-33) is any cut-or-fill requirements, the distance from the center line, and the slope ratio. When it becomes necessary to offset the slope stake, the offset distance from where the slope stake should be is written at the bottom of the offset stake.

Slope stakes indicate the intersection of the cut-or-fill slope with the existing natural groundline and limit of earthwork on each side of the center line (fig. 15-34).

Right-of-Way Stakes

Stakes set on the property line of a construction site are known as **right-of-way stakes.** These stakes mark the boundaries of the site or project. You must not operate equipment outside the property line defined by the right-of-way stakes. The right-of-way stakes are usually marked by the use of colored cloth (bunting) or flagging. Occasionally right-of-way stakes may be marked with the symbol **R/W** (fig. 15-35).

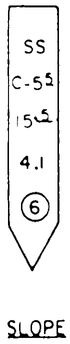


Figure 15-33.—Slope stake.

Finish Grade Stakes

When performing final grading, you are likely to work with stakes called **blue tops.** These are hub stakes, which are usually 2 inches by 2 inches by 6 inches. These hubs are driven into the ground until the top is at the exact elevation of the finished grade as determined by the surveying crew. They are colored with a blue lumber crayon (keel) to identify them as finish grade stakes. Red crayon is normally used to indicate the subgrade elevation. Blue top stakes are placed when the existing grade is within 0.2 feet (2.4 inches) above the final or desired grade. The desired grade is obtained by lowering or raising the compacted grade with a grader until it is flush or even with the top of the hub (fig. 15-36).

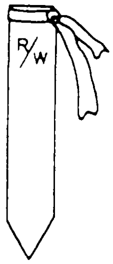


Figure 15-35.—Right-of-way stake symbol.

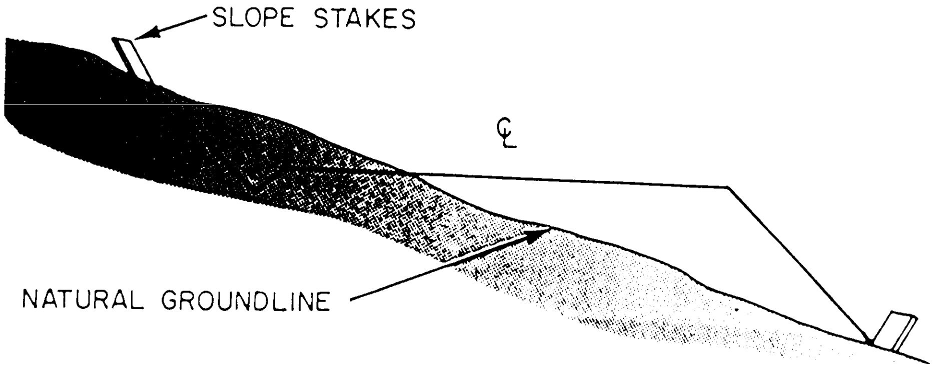


Figure 15-34.—Slope stake set in existing natural groundline.

LEVELING EQUIPMENT

To set, use, and compute grade stake measurements, you must be able to measure the vertical distance from one point to another. This process is called **leveling** and is accomplished by using leveling equipment.

A **level** is an instrument used for measuring vertical distances. All levels have a line of sight with a bubble device for maintaining the instrument in a horizontal plane. Levels vary in their accuracy according to the quality and magnification power of the lens.

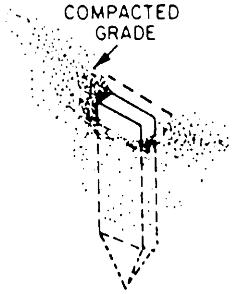

COMPACTED
GRADE

Figure 15-36.—Finish grade stake.

Vertical distances are actually measured by sighting on a graduated rod, called a **level rod.** Like other surveying equipment used for measuring distances, level rods usually are graduated in feet, tenths, and hundredths.

HAND LEVEL

The hand level is generally a round metal tube about 6 inches long with an eyepiece at one end, a cross hair at the other end, and a **level vial** on top (fig. 15-37). Part of the cross-hair end is covered with a mirror that reflects the image of the bubble to the viewer.

To use the hand level, look through the eyepiece end at the rod with the level vial on top. Tilt the entire hand level until the bubble is centered on the cross hair while looking through the eyepiece. It is sometimes necessary to know the height of the level above the ground where you are standing. This may be accomplished by resting the level on a stick of known

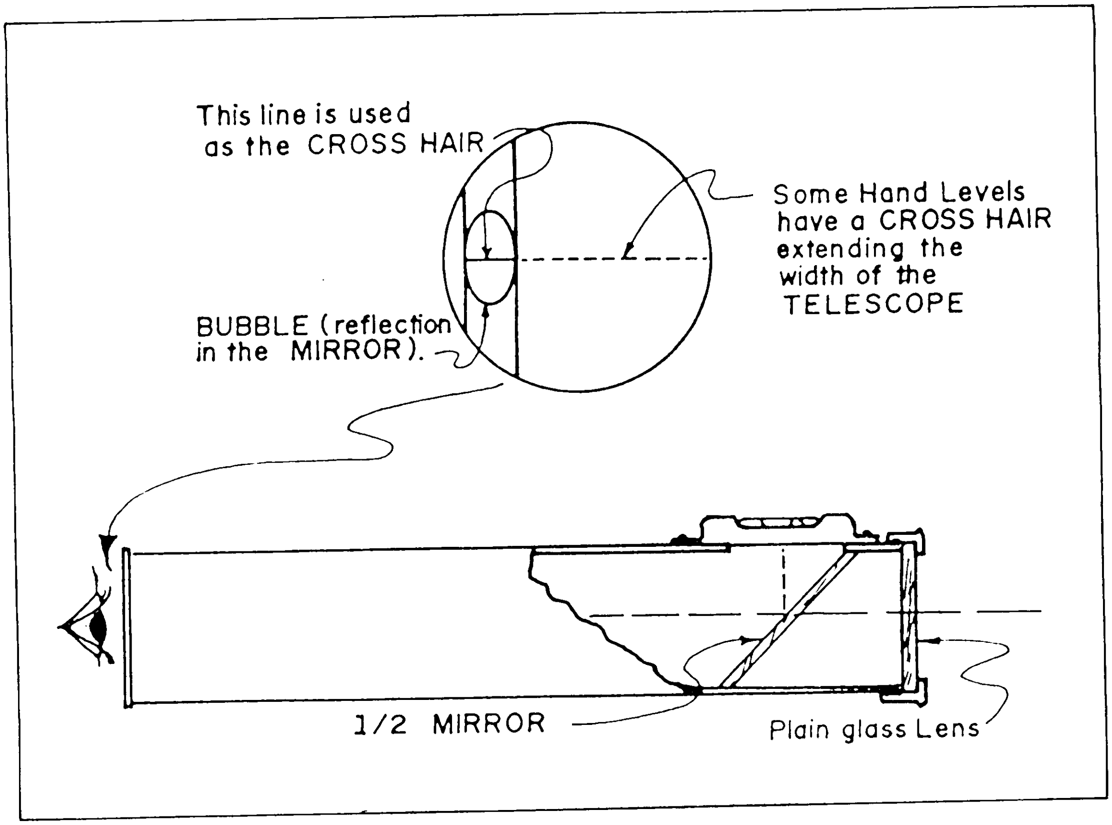

This line is used
as the CROSS HAIR
Some Hand Levels
have a CROSS HAIR
extending the
width of the
TELESCOPE
BUBBLE (reflection
in the MIRROR).
1/2 MIRROR
Plain glass Lens

Figure 15-7.—Hand level.

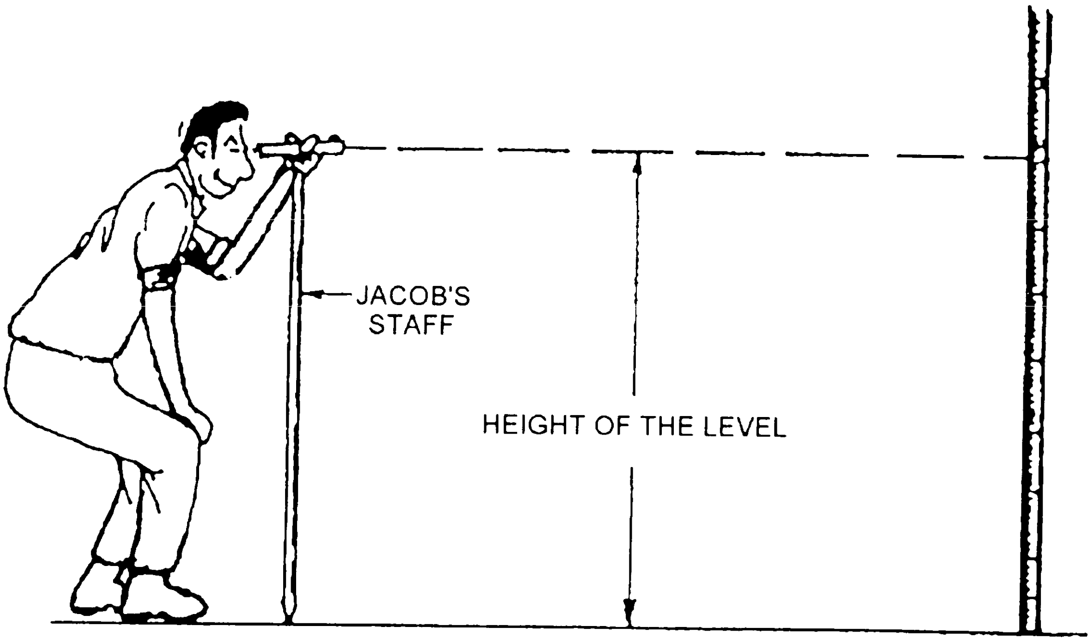

JACOB'S STAFF
HEIGHT OF THE LEVEL

Figure 15-38.—Using a Jacob's staff with a hand level.

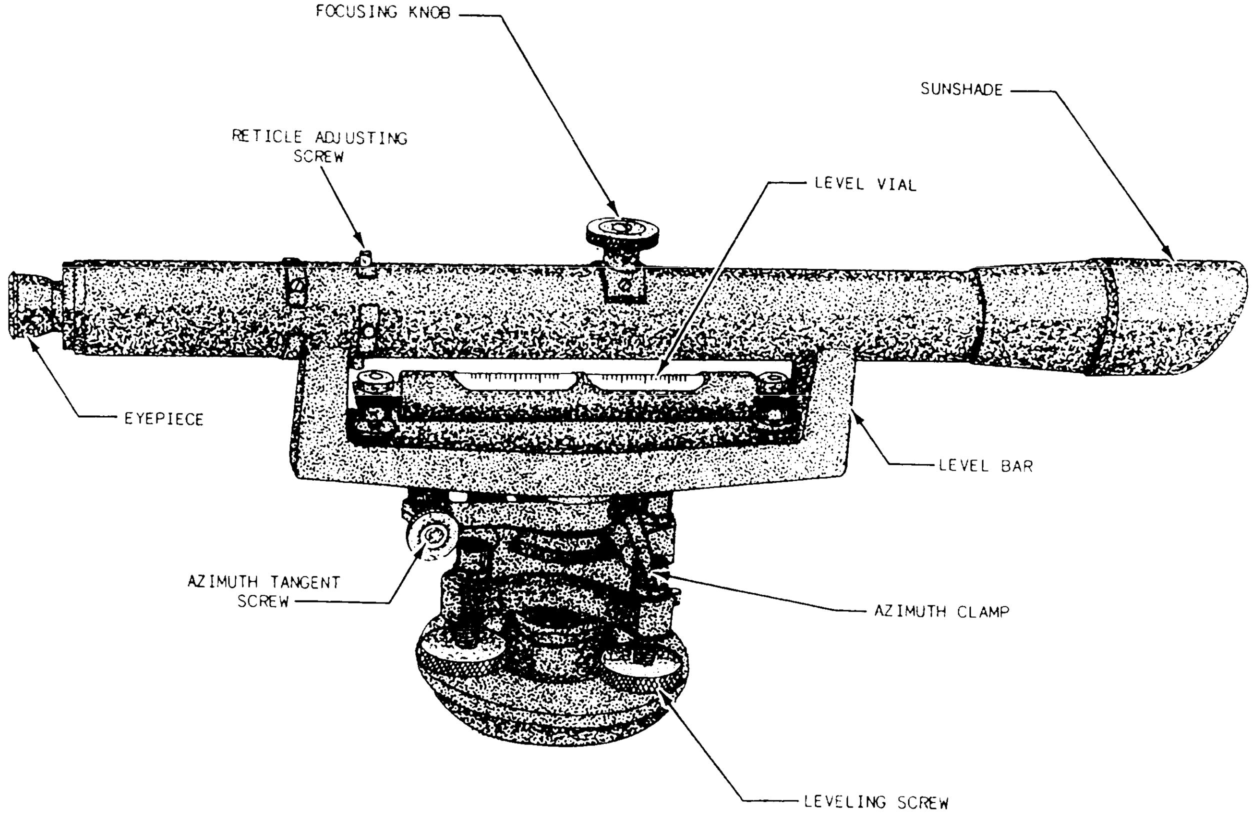

FOCUSING KNOB
SUNSHADE
RETICLE ADJUSTING SCREW
LEVEL VIAL
EYEPIECE
LEVEL BAR
AZIMUTH TANGENT SCREW
AZIMUTH CLAMP
LEVELING SCREW

Figure 15-39.—Dumpy level.

length. This stick is known as **Jacob's staff,** as shown in figure 15-38. For rough work, you may ignore the use of a stick and merely use the height of your eye above the ground in your normal standing position.

The hand level is used for checking grade during the rough or early part of a construction project and is not used at distances greater than about 50 feet or even lesser distances if an accuracy of more than 2 or 3 tenths is required.

DUMPY LEVEL

The dumpy level (fig. 15-39) has its telescope rigidly attached to the level bar, which supports an adjustable, highly sensitive level vial. The cross hairs are brought into focus by rotation of the eyepiece and the focusing knob. The telescope can be exactly trained on the level rod by lightly tightening the azimuth clamp and manipulating the azimuth tangent screw. Depending on atmospheric conditions, the dumpy level can be used to measure vertical distances accurately at distances of 300 feet or less. When used for alignment, it is accurate at distances up to 1,000 feet.

SELF-LEVELING LEVEL

The self-leveling level (fig. 15-40) is a precise, time-saving leveling instrument and is equipped with a small bull' s-eye level and three leveling screws. The leveling screws, which are on a triangular foot plate, are used to center the bubble of the bull' s-eye level.

The line of sight automatically becomes horizontal and remains horizontal as long as the bubble remains approximately centered. A prismatic

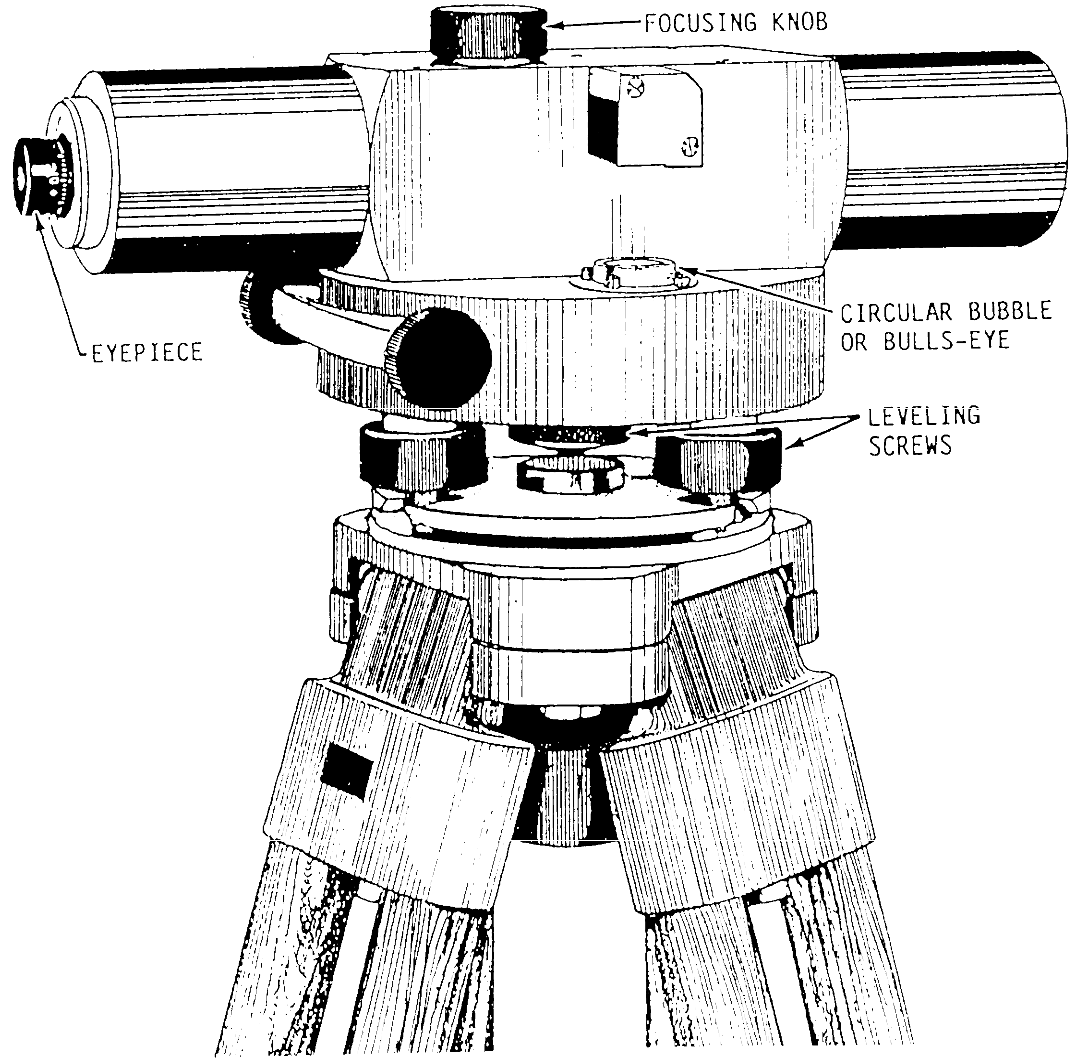


Figure 15-40.—Self-leveling level.

device, called a **compensator** (fig. 15-41), makes this possible. The compensator is suspended on fine, nonmagnetic wires. The action of gravity on the compensator causes the optical system to swing into the position that defines a horizontal line of sight. This horizontal line of sight is maintained despite a slight out-of-level telescope or even a slight disturbance occurs on the instrument.

TRIPOD

The tripod (fig. 15-42) is the base or foundation that supports the level instrument and keeps it stable during observations. A tripod consists of a head to which the instrument is attached, three wooden or metal legs that are hinged at the head, and pointed metal shoes on each leg to be pressed or anchored into the ground to achieve a firm setup.

In setting up the tripod, loosen the restraining strap from around the three legs. An effective way to set the tripod down is to grip it with two of the legs close to your body while you stand over the point where the setup is required. By using one hand, push the third leg out away from your body until it is about 50 to 60 degrees with the horizontal. Lower the tripod until the third leg is on the ground. Place one hand on each of the first two legs, and spread them while taking a short backward step, using the third leg as a pivot point. When the two legs look about as far away from the mark as the third one and all three are equally spaced, lower the two legs and press them into the

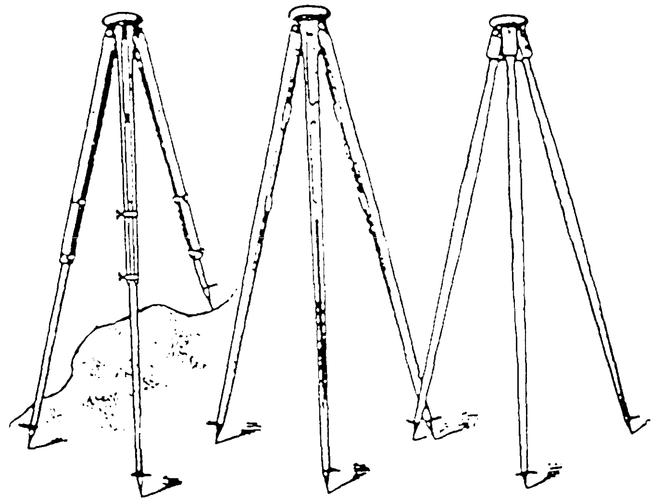


Figure 15-42.—Tripods.

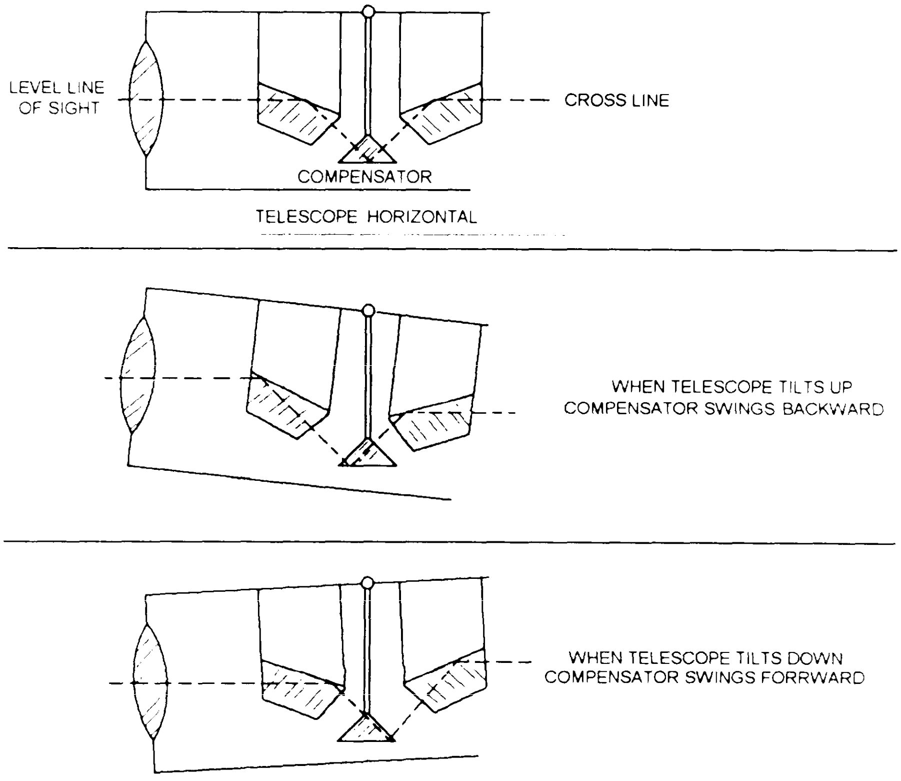

LEVEL LINE OF SIGHT
CROSS LINE
COMPENSATOR
TELESCOPE HORIZONTAL
WHEN TELESCOPE TILTS UP COMPENSATOR SWINGS BACKWARD
WHEN TELESCOPE TILTS DOWN COMPENSATOR SWINGS FORRWARD

Figure 15-41.—Self-leveling level compensator.

ground. Make any slight adjustments to level the head further by moving the third leg a few inches in or out before pressing it into the ground.

When placing the instrument onto the tripod, grip the instrument firmly to avoid dropping it while you are mounting it on the tripod. The instrument should be screwed down to a firm bearing, but not so tightly that it binds or the screw threads strip.

LEVEL ROD

The most often used level rod is the **Philadelphia rod,** as shown in figure 15-43. It is a graduated wooden rod, made of two sections, and can be extended from 7 feet to 13 feet.

Each foot is subdivided into hundredths of a foot. Instead of each hundredth of a foot being marked with a line or tick, the distance between alternate hundredths is painted black on a white background. Thus the distance between the colors: the top of the black is even values, the bottom of the black is odd values, the tenths are numbered in black, the feet in red.

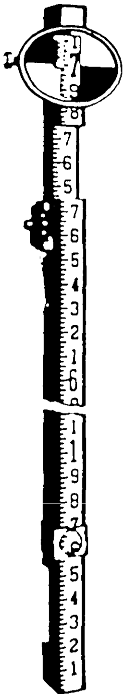


Figure 15-43.—Philadelphia level rod with target.

Direct Reading

Direct readings are taken off a self-reading rod, held plumb on a point by a rodman. If you are working to tenths of a foot, it is relatively simple to read the foot mark below the cross hair and the tenth mark which is closest to the cross hair. But, working to the hundredths of a foot is more complicated. For example, suppose you are making a direct reading which comes out as 5.76 feet. On a Philadelphia rod, the graduation marks are 0.01 foot wide and are 0.01 foot apart. For a reading of 5.76 feet, there are three black graduations between the 5.70-foot mark and the 5.76-foot mark, as shown in figure 15-44. Since there are three graduations, the rod may be misread as 5.73 feet instead of 5.76 feet.

The 5-foot mark or the 6-foot mark does not show in figure 15-44. While sighting through the level instrument, you might not be able to see the foot

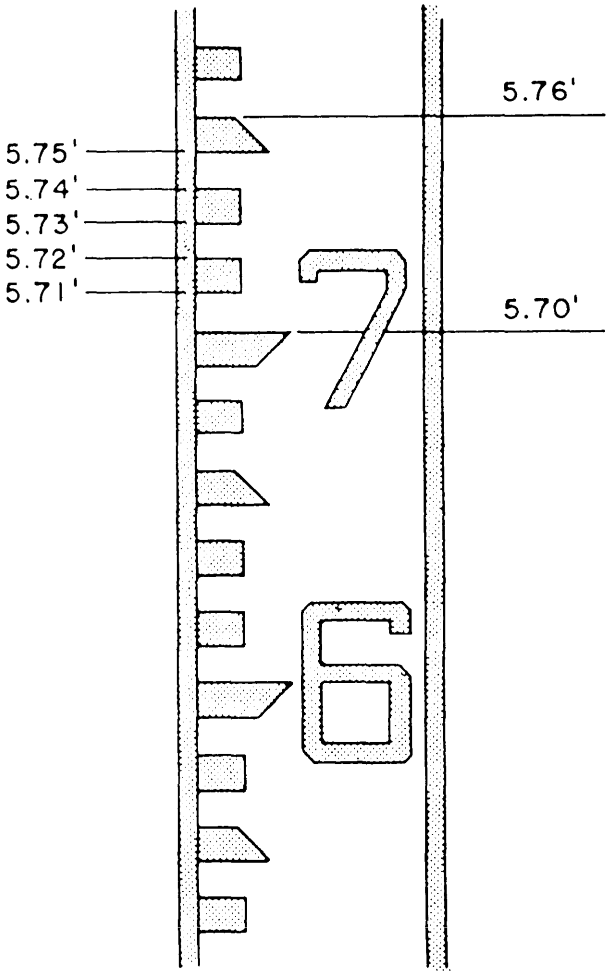


Figure 15-44.—Direct reading of 5.76 feet on a Philadelphia rod.

marks. When you cannot see the next lower foot mark through the level instrument, you signal or ask the rodman to **raise for red.** The rodman should slowly raise the rod until the next lower red number comes into view.

NOTE: The feet measurements on the Philadelphia rod are in red.

Target Reading

Conditions that hinder direct reading, such as poor visibility, long sights, and partially obstructed sights, as through brush or leaves, sometimes make it necessary to use targets. The target is also used to mark a rod reading when numerous points are set to the same elevation from one instrument setup.

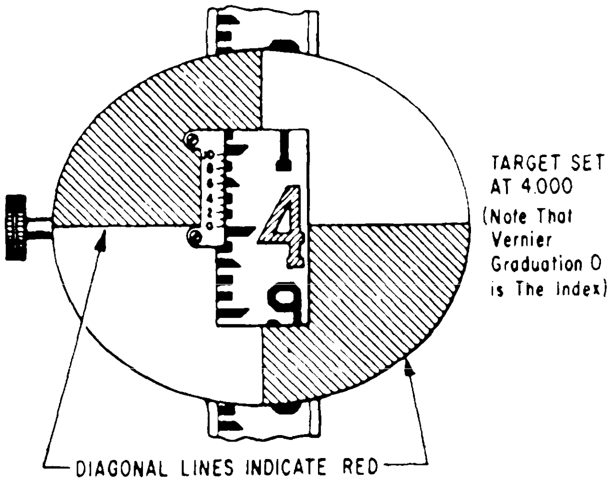

TARGET SET AT 4.000
(Note That Vernier Graduation 0 is The Index)
DIAGONAL LINES INDICATE RED

Figure 15-45.—Target.

Targets (fig. 15-45) for the Philadelphia rod are usually oval, with the long axis at right angles to the rod, and the quadrants of the target painted alternately red and white. The target is held in place by a C-clamp and a thumbscrew. A lever on the face of the target is used for fine adjustment of the target to the line of sight of the level. The targets have rectangular openings approximately the width of the rod and 0.15 feet high through which the face of the rod may be seen. A linear vernier scale is mounted on the edge of the opening with the zero on the horizontal line of the target for reading to thousandths of a foot. When the target is used, the rodman takes the rod reading.

When sighting through the level instrument, the levelman motions either up or down so that the rodman can place the horizontal separation of the target in line with the horizontal cross hair of the instrument. When the horizontal separation and the horizontal cross hair coincide, the levelman waves ALL RIGHT.

After the levelman signals the all right, the rodman tightens the target clamp. Then the rodman holds the rod on the point again to ensure the target has not slipped and "waves" the rod by pushing it about a foot away from and towards his body to see if the rod was initially held in an absolutely vertical position. The levelman should recheck the target reading. If the horizontal cross hairs do not coincide, the target must

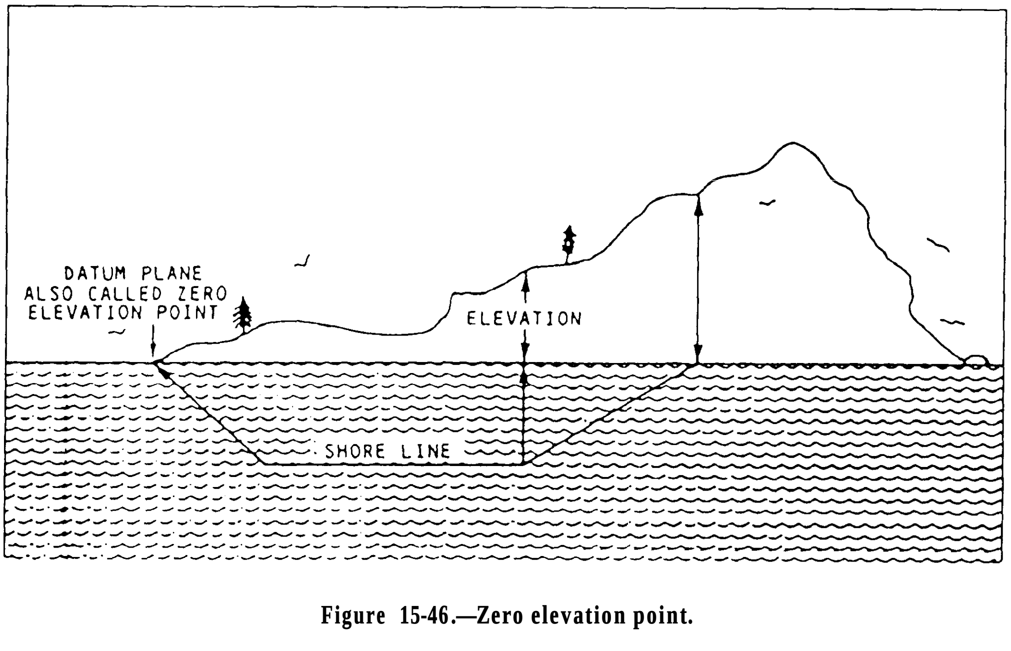


Figure 15-46.—Zero elevation point.

be reset. The rodman reads the target to feet, tenths, and hundredths of the nearest foot gradation below the horizontal quadrant separation line of the target. Equipment Operator's seldom use the vernier scale in earthwork operation.

LEVELING

The vertical distance, measured during leveling, is the **difference of elevation** between two points. The term **elevation** refers to the height of a point or a particular spot above or below a reference line, called a **datum** or **datum plane.**

Datum are of two general types: actual and assumed. An actual datum is **mean sea level** (fig. 15-46). An assumed datum plane is an imaginary level surface assumed to have an elevation of zero. It is used as a convenience in leveling procedures.

A reference point whose elevation is known and marked is called a **bench mark** (B.M.). It is used either as the starting point in leveling or as a point of closure in checking the accuracy of your work.

Bench Marks

Bench marks are classified as **temporary** or **permanent.** Temporaary bench marks (T. B. M.) are established for the use of a particular job and are retained for the duration of that job. Throughout the United States, a series of permanent bench marks has been established by various governmental agencies. These identification markers are set in stone, iron pipe, or concrete and are sometimes marked with the elevation above sea level. Typical markers are shown in figure 15-47.

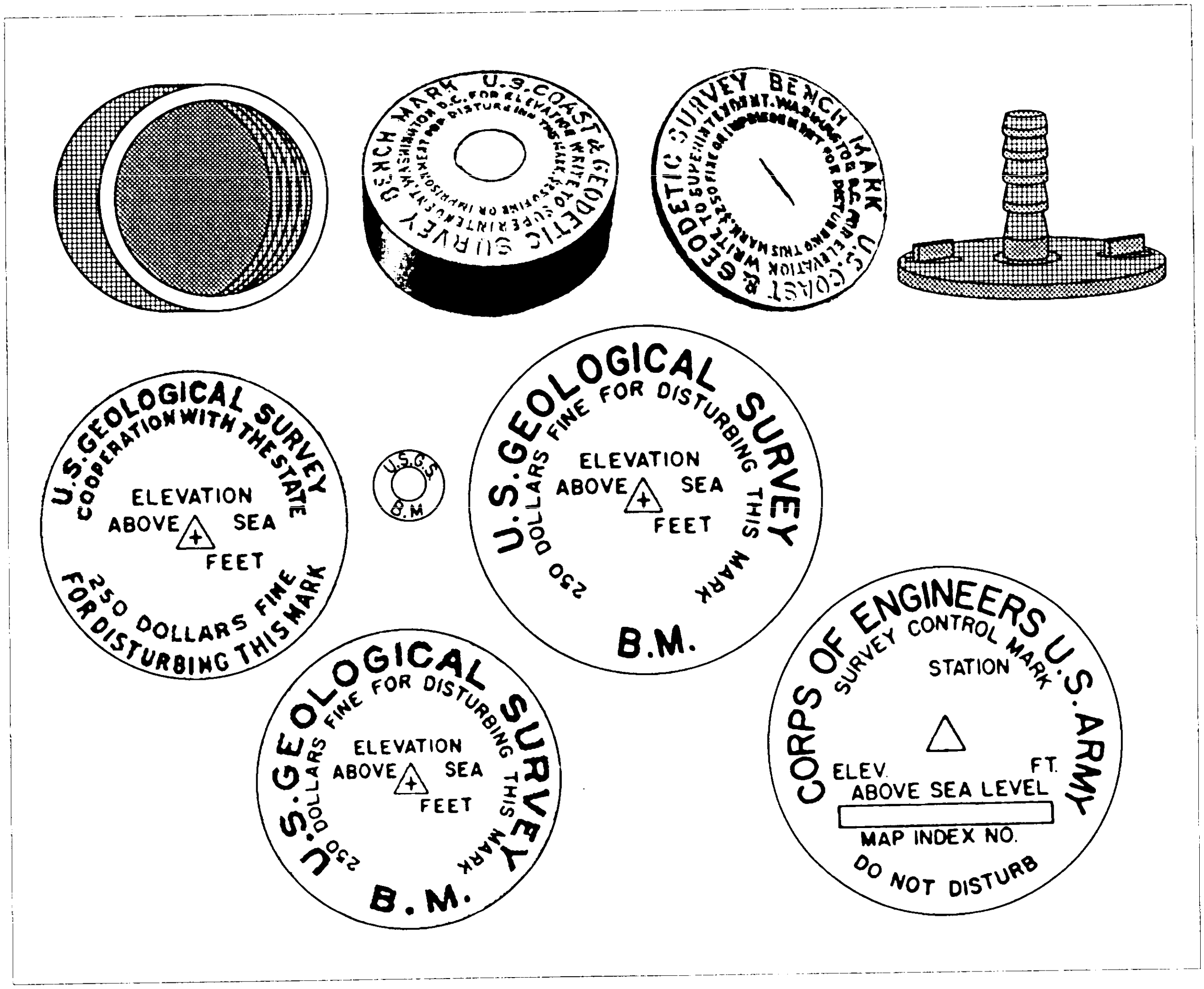

U.S. COAST & GEODETIC SURVEY BENCH MARK
U.S. GEOLOGICAL SURVEY
COOPERATION WITH THE STATE
ELEVATION
ABOVE SEA
FEET
250 DOLLARS FINE FOR DISTURBING THIS MARK
U.S.G.S.
B.M.
U.S. GEOLOGICAL SURVEY
FINE FOR DISTURBING THIS MARK
ELEVATION
ABOVE SEA
FEET
250 DOLLARS
B.M.
CORPS OF ENGINEERS U.S. ARMY
SURVEY CONTROL MARK
STATION
ELEV.
FT.
ABOVE SEA LEVEL
MAP INDEX NO.
DO NOT DISTURB

Figure 15-47.—Federal bench marks.

Any substantial object may be used as a bench mark. Figure 15-48, view A, shows typical monuments set to mark important alignment points, but which may also be used as bench marks. Spikes may be driven into posts or power poles, as shown in figure 15-48, view B, or chiseled into stone or concrete structures, as shown in figure 15-48, view C. For clarity, the marks are shown on the wing wall; but in practice, one mark only is usually chiseled or spray-painted on a flat surface.

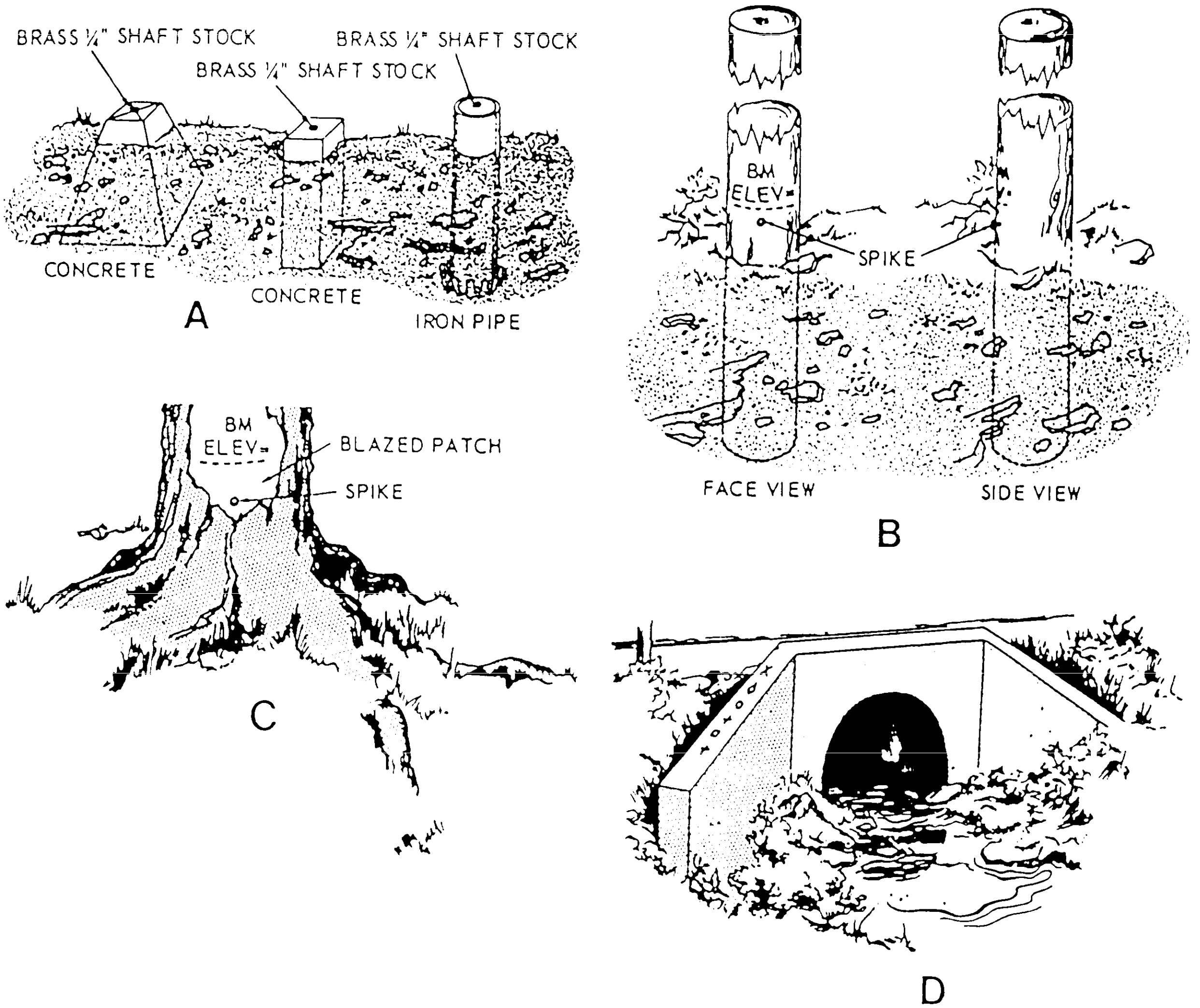
The location, elevation, and description of bench marks are usually shown on the project drawings or in the surveyor's field notes.

Determining Elevations

Once a bench mark is established, certain formulas are used for determining elevations. You first must figure the height of the instrument. This is done by taking a reading on a level rod that is placed on a known elevation, such as a bench mark. This is known as a **backsight (BS).**

To determine the height (HI) of the instrument, add the bench mark (BM) elevation to the backsight (BS) reading from the level rod. This formula is written as **HI** = **BM** + **BS.**

For example, as shown in figure 15-49, the bench mark elevation is 100.00 feet. The backsight reading


BRASS ¼" SHAFT STOCK
BRASS ¼" SHAFT STOCK
BRASS ¼" SHAFT STOCK
CONCRETE
CONCRETE
IRON PIPE
A
BM
ELEV.=
SPIKE
FACE VIEW
SIDE VIEW
B
BM
ELEV.=
BLAZED PATCH
SPIKE
C
D

A Horizontal control monuments
B Spike in a post or pole
C Spike in a tree
D Chiseled mark on concrete

Figure 15-48.—Temporary bench marks.

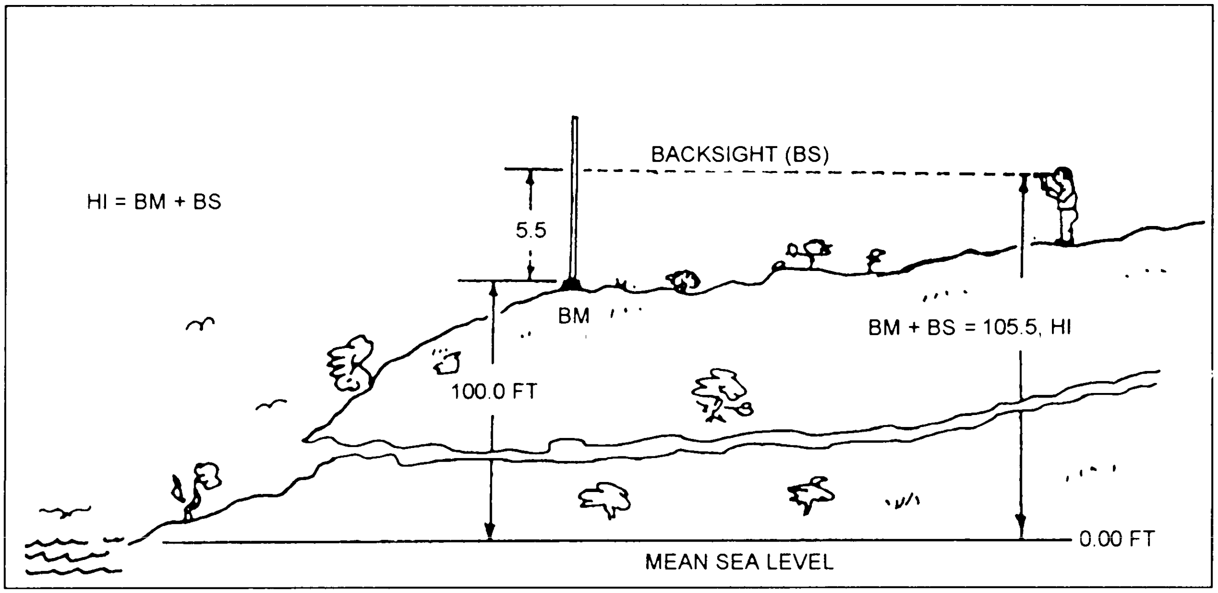
is 5.5 feet. The bench mark elevation, added to the backsight reading, gives a instrument height of 105.5 feet.

NOTE: Since the backsight (BS) reading is added to the elevation of the bench mark (BM) to obtain the instrument height, it is usually called a plus (+) sight.

Once the height (HI) of the instrument is established, you can determine the elevation of any point within the instrument range.

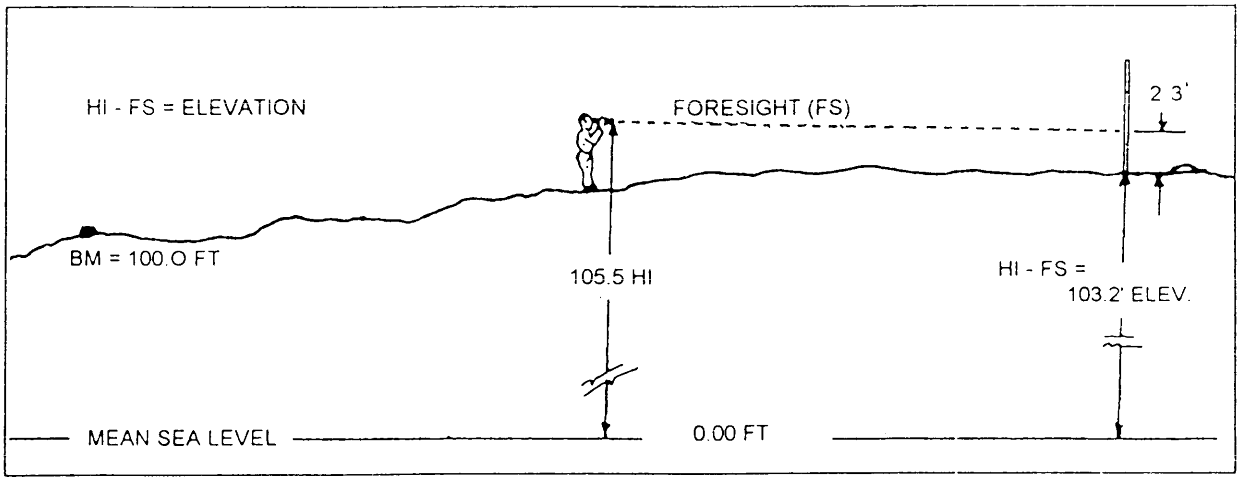
To determine the elevation of a point after the height (HI) has been established, place the level rod on the point in question and take a reading through the level. This sighting is called the **foresight (FS)** reading and is subtracted from the height to obtain the elevation of the point. The formula for determining elevation is as follows: **HI - FS = EL**

For example, as shown in figure 15-50, the height (HI) of the instrument is 105.5 feet. The foresight (FS) reading is 2.3 feet. The instrument height minus the foresight reading gives that point an elevation of 103.2 feet.



HI = BM + BS
BACKSIGHT (BS)
5.5
BM
BM + BS = 105.5, HI
100.0 FT
0.00 FT
MEAN SEA LEVEL

Figure 15-49.—Backsight reading to determine instrument height.



HI - FS = ELEVATION
FORESIGHT (FS)
2 3'
BM = 100.0 FT
105.5 HI
HI - FS =
103.2' ELEV.
MEAN SEA LEVEL
0.00 FT

Figure 15-50.—Foresight reading to determine elevation.

Checking Grade with a Level Instrument

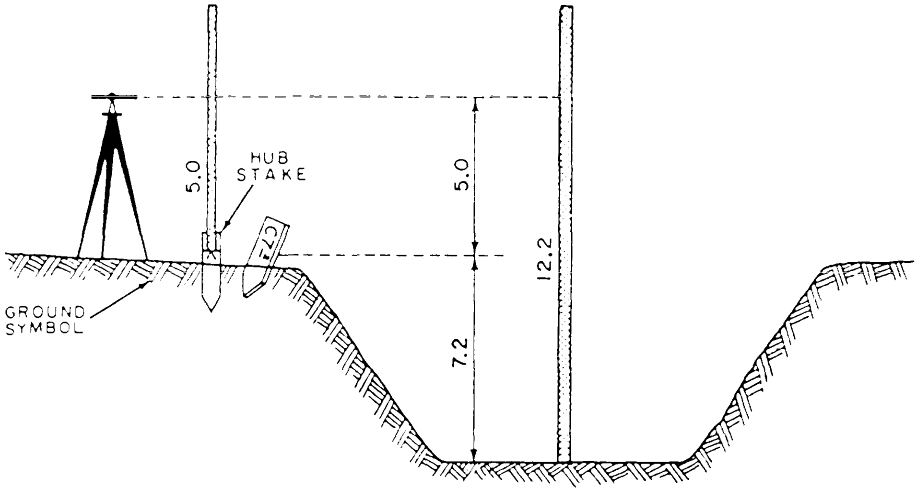
An example of checking ground spots for desired grade with a level instrument is shown in figure 15-51.

The hubs and stakes at the side of the construction represent offset grade stakes. In figure 15-51, view (A), the grade stake calls for a cut of 7.5 feet. You set up your level and take two readings: first on the hub and then on the excavation. Your first reading is 5.0 feet. Since the excavation is supposed to be 7.5 feet below the hub, your second reading should be 12.5 (5.0 plus 7.5 as shown). But the rod reads only 12.2; therefore, you must cut 0.3 feet more to get to finished subgrade.

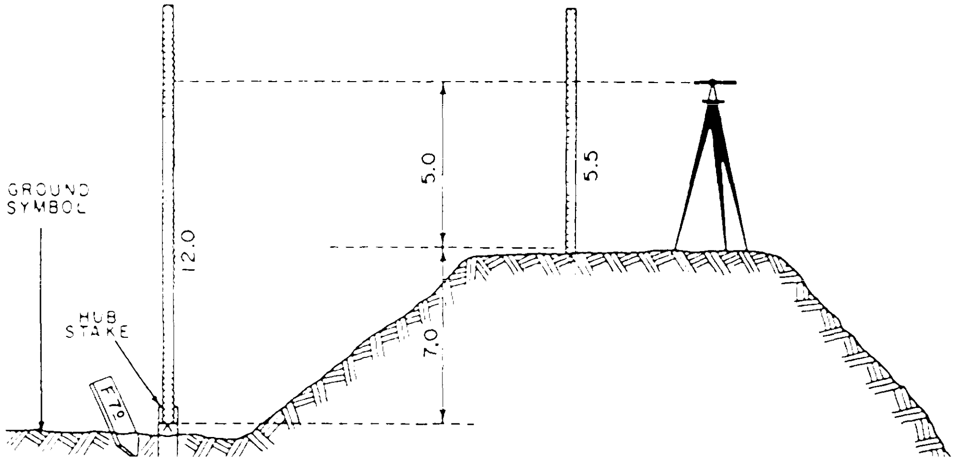
In figure 15-51, view (B), your first reading is 12.0 feet on the hub. Since the stake calls for F 7.0, you should read 5.0 on the completed fill. But the rod reads 5.5; therefore, you must fill another 0.5 feet to finish the subgrade.

MISSING GRADE STAKE.— Another leveling procedure is to compute a cut-or-fill requirement from a missing grade stake. In figure 15-52, the finish elevation from the project drawings at point B is supposed to be 378.75. You setup your level, take a backsight shot on the bench mark at point A, and get a direct reading of 11.56 feet. The 11.56 feet backsight reading plus the bench mark elevation of 365.01 feet gives you an instrument height of 376.57 feet. Then you take a foresight shot at point B, and get a direct reading of 1.42 feet. You now subtract the foresight reading of 1.42 feet from the instrument height of 376.57, and find that the existing ground is at elevation 375.15. You now take the required finish elevation of 378.75 and subtract the existing elevation of 376.15 and get a FILL requirement of 3.6 feet at point B. If the existing elevation is greater than the required finish elevation, you would be required to cut.

Another example of a missing grade stake is shown in figure 15-53. Suppose the stake at station 4 + 50 has been knocked out, and there is no bench mark



(A) CHECKING CUT



(B) CHECKING FILL

Figure 15-51.—Checking cut and fill.

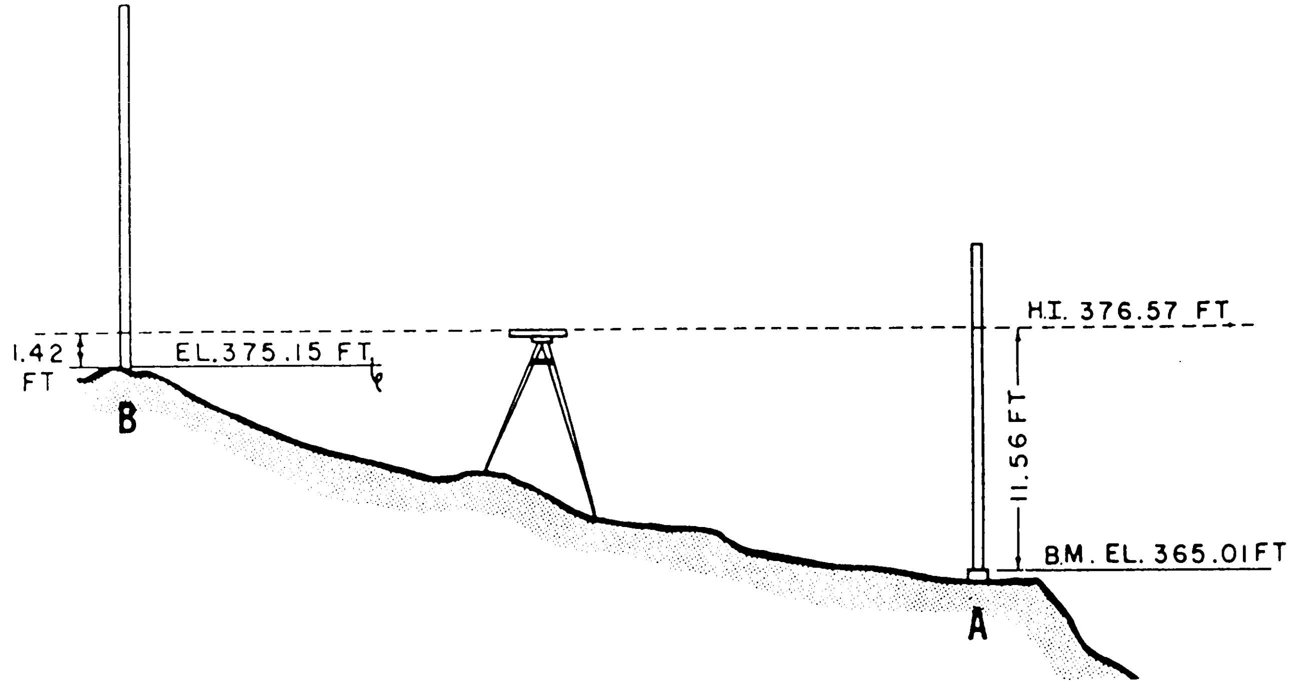

1.42 FT
EL.375.15 FT
B
H.I. 376.57 FT
11.56 FT
B.M. EL. 365.01 FT
A

Figure 15-52.—Computing cut-or-fill requirement from a missing grade stake.

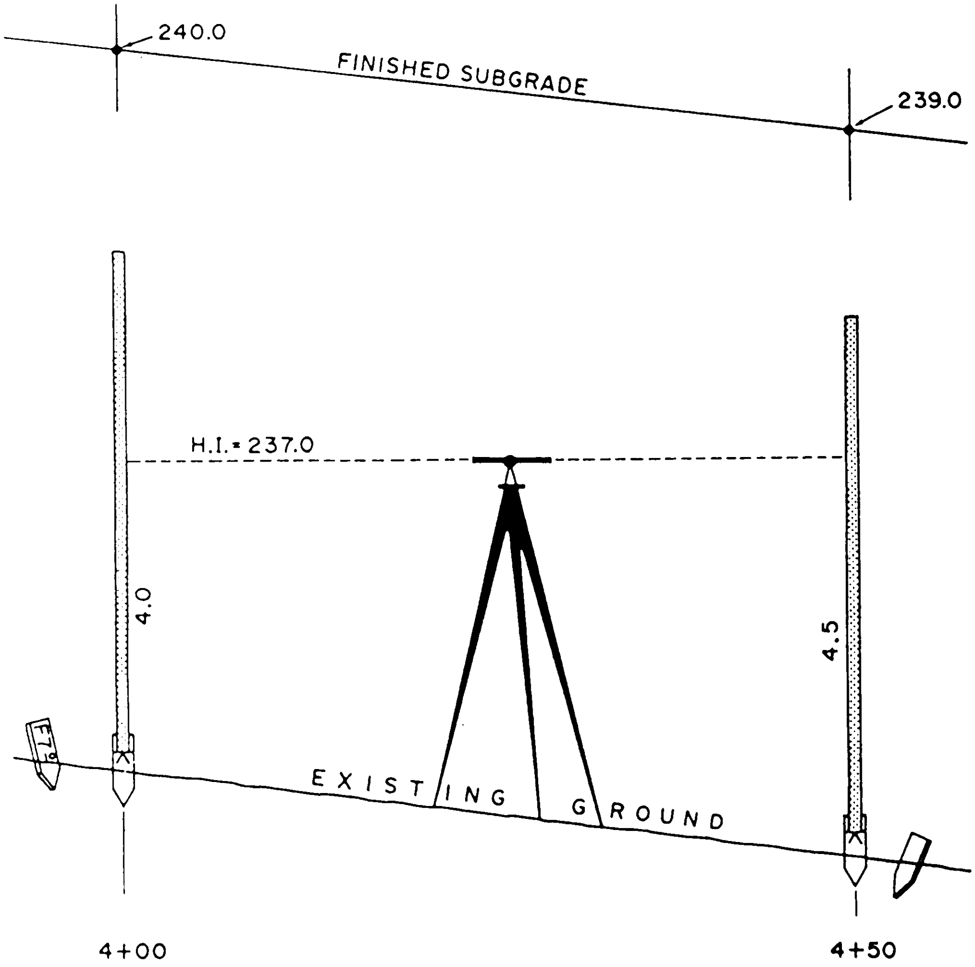

240.0
FINISHED SUBGRADE
239.0
H.I.= 237.0
4.0
4.5
F 7
EXISTING GROUND
4+00
4+50

Figure 15-53.—Replacing a missing grade stake.

nearby, but you do have a nearby grade stake at station 4 + 00 and a set of the project drawings.

At station 4 + 00, the project drawings call for a subgrade elevation of 240.0 feet. The stake at station 4 + 00 calls for a fill of 7.0 feet; therefore, the existing elevation at station 4 + 00 is 233.0 (7.0 feet below 240.0).

You set up your level and take a backsight direct reading on station 4 + 00 of 4.0 feet. The backsight reading of 4.0 feet plus the existing known elevation of 233.0 feet gives an instrument height of 237.0. Then you take a foresight shot on station 4 + 50 and get a direct reading of 4.5 feet. You subtract the foresight reading of 4.5 feet from the instrument height of 237.0 feet, and you get at station 4 + 50, the existing elevation of 232.5 feet.

The project drawings show that the finished subgrade elevation at station 4 + 50 is 239.0 feet. With the existing elevation at 232.5, you must FILL at station 4 + 50 a total of 6.5 feet to reach the 239.0 feet required subgrade elevation. Therefore, you should place a grade stake at station 4 + 50 that is marked F 6.5.

TURNING POINT.— The two missing grade stake examples were based on elevations of nearby points that could be read from one setup of the level. If differences of elevation or distance are too great or if there are obstructions, you will have to make an intermediate setup and sight on a point, called a **turning point (T.P.).** Any convenient point may be used as a turning point, but the level rod must be set on firm ground or on some firm object so that the elevation of the T.P. will not change while the rodman waits for the levelman to setup at the new position.

An example of a level run is shown in figure 15-54. You have a B.M. at the bottom of a bank and you want to find the elevation at the top of the bank, which is point A. You cannot set up on the top of the bank to take a reading on the level rod held on point A because to take a backsight shot on the B.M., the level rod is too short.

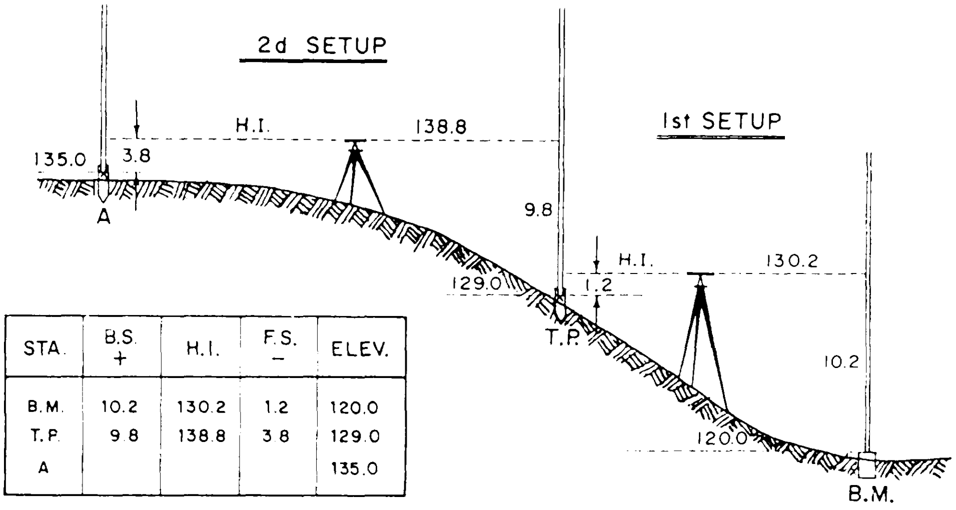
First, record the B.M. elevation of 120.0 feet. Next, set up the level instrument on the bank and take a backsight shot on the B.M. to get a level rod reading of 10.2 feet. Add the backsight shot of 10.2 feet to the B.M. elevation of 120.0 feet to get the first instrument height of 130.2 feet. Then take a foresight shot on the T.P. to get a level rod reading of 1.2 feet. Subtract the 1.2 feet foresight reading from the 130.2 feet instrument height to get a T. P. elevation of 129.0 feet.

Next, move the instrument to the top of the bank. Take a backsight shot on the T.P. to get a level rod reading of 9.8 feet. Add the 9.8 feet backsight reading to the 129.0 feet T.P. elevation to get a second instrument height of 138.8 feet. The last step is to take a foresight shot on point A to get a level rod reading of 3.8 feet. Subtract the 3.8 feet foresight reading from the 138.8 feet second instrument height to get a 135.0 feet point A elevation.

Some level runs may require more than one T. P.; however, no matter how extensive the job, the procedure is always the same: you add and subtract successive rod readings from a point of known elevation to the point of unknown elevation.

MEASURING HORIZONTAL DISTANCES

Setting or replacing grade stakes requires measuring horizontal distances with either a **woven tape** or a **steel tape.**



STA.	B.S. +	H.I.	F.S. −	ELEV.
B.M.	10.2	130.2	1.2	120.0
T.P.	9.8	138.8	3.8	129.0
A				135.0

Figure 15-54.—Turning point and level notes.

A woven tape (fig. 15-55) is made of high-grade cloth (usually linen) fabric. A metallic, woven tape is reinforced with fine bronze or brass wire mesh. A nonmetallic, woven tape does not contain the mesh; however, some nonmetallic, woven tapes are coated with plastic.

Woven tapes are made in 25-, 50-, 75-, 100-, and 150-foot lengths. Some are graduated in feet and inches to the nearest quarter inch. Others are graduated in feet and decimals of a foot to the nearest 0.05 foot. On most decimally graduated woven tapes, only the 0.10-foot graduations are marked with numerals.

The steel tape is used for measurements requiring greater precision than is possible with the woven tape. The most commonly used steel tape is 100 feet in length and is graduated in feet, tenths, and hundredths. Some steel tapes are graduated throughout; on others, only the first foot is graduated in subdivisions and the body of the tape is graduated only at every 1-foot mark. A steel tape is sometimes equipped with a reel on which the tape can be wound. The tape can be detached from the reel for more convenient use in taping.

For convenience in carrying from one place to another, a detached tape can be made up into a coil, commonly called “DOING UP’ the tape. This is done by placing the 100-foot end (or the 200-foot, 300-foot, etc., end) in your left hand, faceup; then reach back with your right hand, grasp the 95-foot mark, bring it up, and place it faceup on top of the 100-foot mark. Do the same with the 90-foot mark, the 85-foot mark, the 70-foot mark, and so forth, until you have gathered in the entire tape. You will find that the tape now forms a figure-of-eight, as shown in figure 15-56. The figure-of-eight can be formed into a circular coil, as shown in figure 15-57.

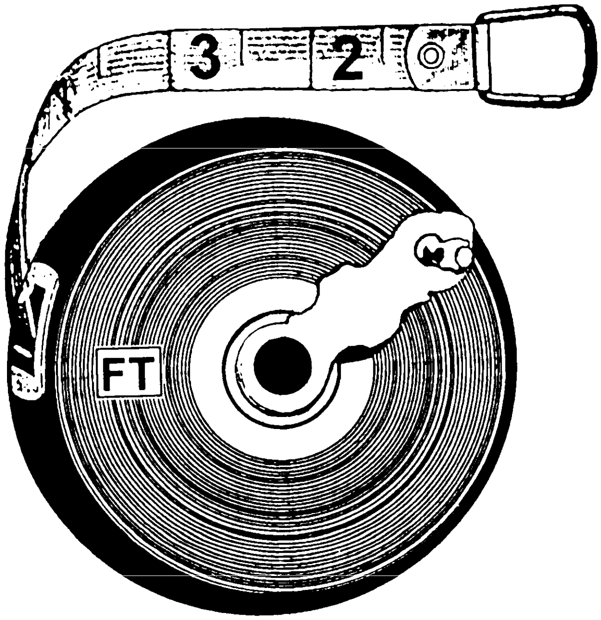


Figure 15-55.—Woven tape.

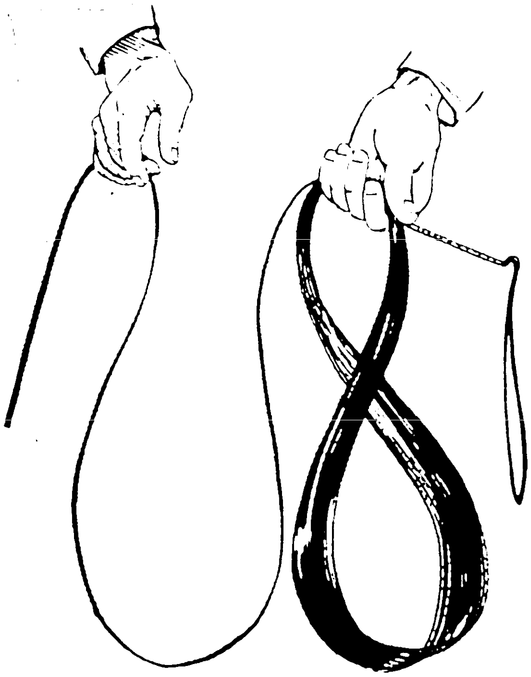


Figure 15-56.—Doing up a steel tape.

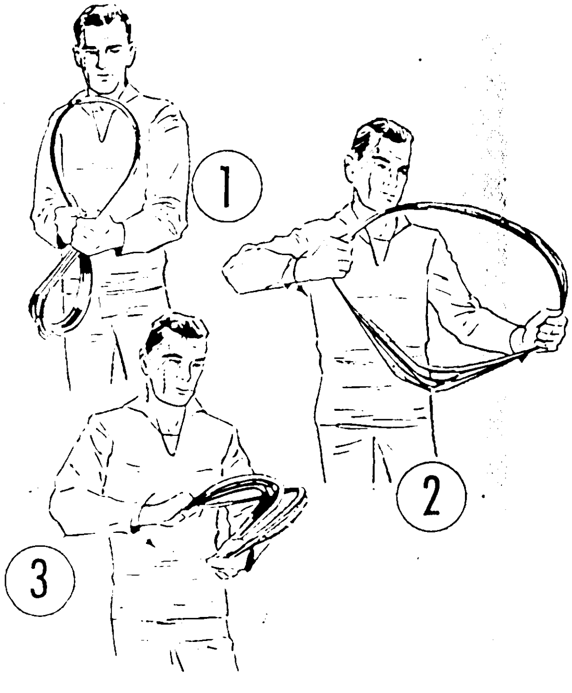


Figure 15-57.—Steps in throwing a steel tape into a coil.

ERRORS AND MISTAKES

Some of the common errors and mistakes made in leveling are as follows:

- Inaccurate adjustment of the instrument: The most common instrument error is caused by a level out of adjustment. The instrument must be adjusted, so the line of sight is horizontal when the bubble is in the center of the tube.

- Errors in sighting: If the eyepiece of the telescope is not properly focused, the rod reading appears to change, because the position of the eye is changed with respect to the eyepiece.

- Errors due to changes in the position of the instrument: When the instrument is not properly leveled or if it is set up in an unstable position, errors due to settlement will result. An unstable instrument setup makes the level bubble tremble slightly, even though it appears to be properly centered. Check the position of the bubble before and after each rod reading to make sure that the bubble has remained in the center of the tube.

- Faulty handling of the rod: The rod may not be properly plumbed. If the rod is not held plumb, such as if it leans toward or away from the instrument, the result will be an excessive reading.

- Erroneous rod length: Check the length of the extended leveling rod with a steel tape.

- Failure to clamp the rod at the proper place when an extended leveling rod is used: This error could result in reading the wrong mark on the rod or reading the wrong cross hairs. Inspect the clamped positions before and after each sight to make sure that the extended rod has not slipped down.

SOILS

The soil is an important part of a solid foundation. A poor foundation will eventually cause roads, runways, buildings, and other temporary or permanent structures to collapse.

SOIL FORMATION

Soils are formed through the breakdown of a solid rock mass or parent material into smaller particles, You may have seen rocks that have been crumbled up or that were softer than others. This is one step in the breakdown of rock into soil. Rocks wear away when they are in contact with moving water, as seen in stream beds or rivers. Rocks also break up when they freeze and thaw. When rocks heat up by the sun and then cool quickly, they crack.

Soil Profile

During formation, soils are in a natural profile made up of three distinct layers (fig. 15-58).

The upper layer, A-horizon, is made up mostly of organic materials. Because these materials are spongy, drain poorly, and do not compact, they are normally removed before building anything on this layer.

The B-horizon lies directly beneath the view A-horizon. This layer is lighter in color and is made up of sand, gravel, silt, and clay. Seldom is soil in its natural state made up of only sand, gravel, silt, or clay. Most soil is made up of a mixture of the four. How strong and free-draining the soil is depends on the type and amount of each in the mixture. The B-horizon is usually the base for all types of pavement construction.

The C-horizon is rock in its natural state. It is sometimes called **parent** material, because this is where B-horizon material comes from. Very seldom are projects built on the C-horizon.

Soil Properties

With experience, you will learn that you can use different properties of soil to your advantage. Soil properties are as follows:

- Expansion
- Contraction
- Plasticity
- Cohesion

Expansion and contraction are undesirable characteristics for a solid foundation that must be monitored closely. Clays and some forms of silt expand and contract with changes in moisture content. Plasticity is the ability of a soil to be molded into shapes. Some clays and silts are also plastic and can be a problem if not controlled properly. Cohesion is the ability of soil to stick together when dry, and a good example are clays which are very cohesive. The more plastic a soil is when wet, the more cohesive it is when dry.

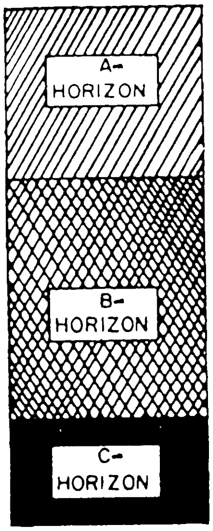


Figure 15-58.—Soil profile.

Soil Classification

The soils you normally work with in earthwork operations are classified as follows:

- Coarse grained
- Fine grained
- Organic

COARSE-GRAINED SOILS.— Soils in this classification are composed of sand and gravel and are in the B-horizon. Coarse-grained soils have 50 percent or less material passing the No. 200 sieve. Their grain shape varies from rounded to angular and has good load-bearing qualities and drains freely.

FINE-GRAINED SOILS.— Fine-grained soils are composed of silt and clay and are in the B-horizon. They have 50 percent or more material passing the No. 200 sieve. Fine-grained soils have good-load bearing qualities when dry; however, these soils drain poorly, and when wet, have little or no load-bearing strength. This characteristic is especially true with clay.

ORGANIC SOILS.— Organic soils, sometimes referred as **top soil,** are composed mostly of decayed plant and animal matter and are in the A-horizon. These soils retain moisture, are difficult to compact, and are normally used when landscaping a finish project.

Soil Sizes

Soils are grouped by the size of their particle grains. One method used to distinguish sizes is through the use of sieves (fig. 15-59). A sieve is a screen attached across the end of a cylindrical metal frame. The screen allows particles smaller than its openings to fall through and retains larger particles. Sieves with screen openings of different sizes allows you to sort soil into particle groups, based on size.

Sieve sizes are designated by the screen opening size; for example, a 3-inch sieve has a screen with openings 3 inches square. A No. 4 sieve has four openings per linear inch, thus having 16 openings per square inch.

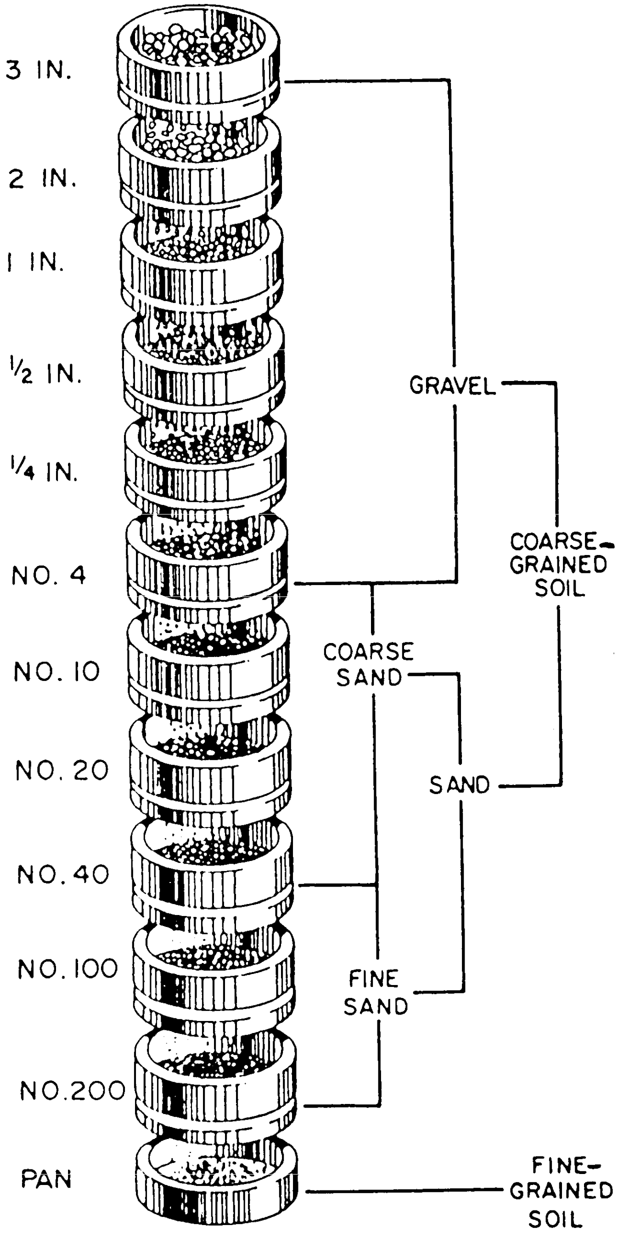


Figure 15-59.—Standard sieve set.

If a soil sample passes the 3-inch sieve but does not pass the No. 4 sieve, the larger particle size is less than 3 inches and the smallest size is larger than 1/16 inch. This soil is classified as gravel.

Soils that pass the No. 4 sieve but are retained on the No. 200 sieve are classified as sands. Sands are further broken down as coarse sand or fine sands. Coarse sand passes the No. 4 sieve and is retained on the No. 40 sieve. Fine sand passes the No. 40 sieve and is retained on the No. 200 sieve.

Any soil, passing the No. 200 sieve, is classified as fine-grained.

Soil Gradation

Gradation describes the distribution of different size groups within a soil sample. A **well-graded soil** (fig. 15-60) is a soil sample that has all sizes of material present from the No. 4 sieve to the No. 200 sieve.

Poorly graded soil may be **uniformed-graded** (fig. 15-61) or **gap-graded** (fig. 15-62). If a soil is uniformed-graded, most of its particles are about the same size. An example of this is a sieve analysis in which sand size No. 20 is the only size present.

If a soil is gap-graded, at least one particle size is missing. An example of gap-graded soil is one in which a sieve analysis reveals that sand sizes No. 10 and No. 40 are missing. All other sizes are present.

Soil Compaction

Compaction is pressing together soil particles to form a consolidated mass with increased stability.

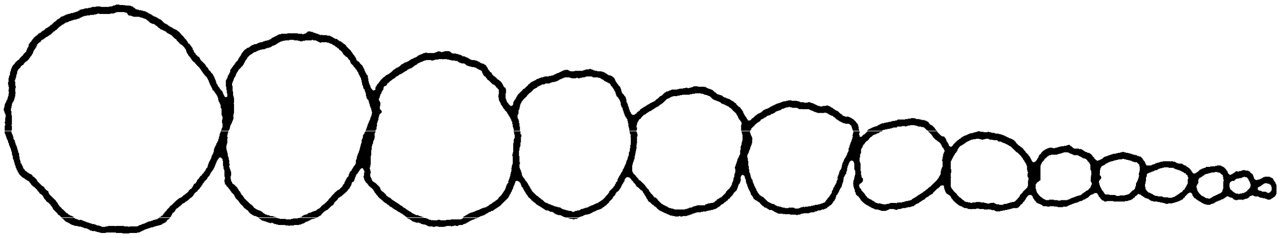


Figure 15-60.—Well-graded soil.

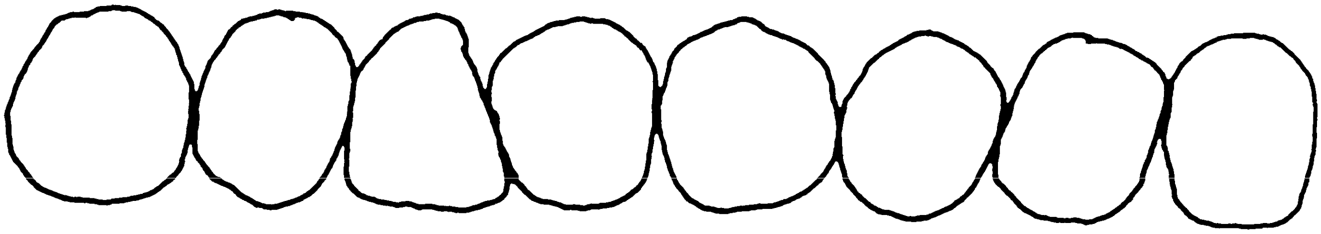


Figure 15-61.—Uniform-graded soil.

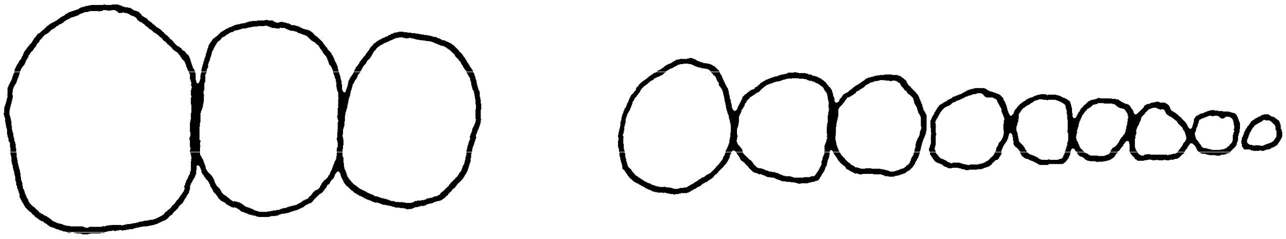


Figure 15-62.—Gap-graded soil.

Compaction helps the soil to be more resistant to soaking up moisture from below.

Fills are built up in compacted layers. In earthwork operations, these layers are called **lifts.** Lifts are from 4 inches to 1 foot in depth, depending upon the compaction necessary, compaction equipment available, and material used for the fill.

The fill material must have the right amount of moisture, referred to as **optimum moisture content.** To obtain maximum compaction, wet the fill, when necessary, before it is compacted. Compaction may be obtained by using a pneumatic, tandem, or vibratory roller.

SOIL STABILIZATION

There are three purposes for soil stabilization. The first one is strength improvement. This increases the strength of the existing soil to enhance its load-bearing capacity. The second purpose is for dust control. This is done to eliminate or alleviate dust, generated by the operation of equipment and aircraft during dry weather or in arid climates. The third purpose is soil waterproofing, which is done to preserve the natural or constructed strength of a soil by preventing the entry of surface water.

There are two methods used to apply soil stabilization materials. The first is the admix way. This is used where it is necessary to combine two different soils together for stabilization. This can be done as follows:

- In-place mixing: accomplished by blending of soil and stabilization materials on the jobsite.
- Off-site mixing: accomplished by using stationary mixing plants.
- Windrow mixing: accomplished by mixing the materials using a grader.

The second way is the surface penetration application, which is accomplished by placing a soil treatment material directly to the existing ground surface by spraying or other means of distribution. Some of the additives used in soil stabilization are cement, lime, bituminous products, and calcium chloride. Cement-treated bases are the most commonly used for the purpose of upgrading a poor quality soil. Soil-cement is a mixture of pulverized soil and measured amounts of portland cement and water, compacted to a high density.

There are three types of soil-cement. The first type is compacted soil-cement that contains sufficient amounts of cement to harden the soil and enough moisture for both compaction and hydration of the cement. The second type is cement modified soil which is an unhardened or semihardened mixture of soil and cement. Only enough cement is used to change the physical properties of the soil. The third is plastic soil-cement. It is a hardened mixture of soil and cement that contains at the time of placing, enough water to produce a consistency similar to that of plastering mortar. The three basic materials needed when working with soil-cement are soil, portland cement, and water. The soil can almost be any combination of gravel, sand, silt, or clay.

Three major control factors when working with soil-cement are as follows:

1. The proper cement content is needed. A rule of thumb: use one 50-pound bag per square yard.

2. Proper moisture content. On a soil sample, a firm cast should be made when squeezed in your hand without squeezing out any water.

3. Adequate compaction. The principles of compacting soil-cement are the same for compacting the same soils without cement treatment. The soil-cement mixture at optimum moisture content should be compacted to maximum density and finished immediately. Moisture loss by evaporation during compaction, as indicated by the graying of the surface, should be replaced with light applications of water.

Occasionally during compaction, the treated area may yield under the compaction equipment. This may be due to one or more of the following causes: (1) the soil-cement mix is much wetter than optimum moisture content, (2) the soil may be too wet and unstable, and (3) the roller may be too heavy for the soil. If the soil-cement mix is too damp, it should be aerated by using the scarifier on the grader. After it has dried to near optimum moisture content, then it is compacted.

TECHNIQUES OF EARTHWORK OPERATIONS

Techniques of earthwork operations consist of knowing the equipment needed and the operations of pioneering, clearing, grubbing, stripping, draining, and grading and excavating. These operations are done primarily with heavy construction equipment, such as bulldozers and graders. Hand- or power-felling equipment, explosives, and fire are used when they make the completion of these operations easier.

CAUTION

> Large-scale clearing and grubbing operations often produce damaging environmental effects, such as increased soil erosion, reduction of atmospheric oxygen, and destruction of wildlife habitat. Additionally, introduction of particulate matter into streams and riverbeds causes increased siltation and algae growth. Federal regulations may require an environmental impact statement or assessment prior to beginning clearing operations.

To prevent these damaging effects, save as much vegetation as possible, such as trees, grass, and other plants, to hold the soil in place. Constructing a shallow trench or application of plastic barriers or hay bales around the perimeter of a project will help to contain water runoff into streams and rivers, preventing siltation. Burning of scrubs and stumps should be done only when atmospheric conditions are favorable and the material to be burned is dry, However, **do NOT** use petroleum base fuels to start fires, as fuels do not burn completely and seep into the underground water table.

NOTE: A burn permit is required in all burning operations on NCF projects to prevent wild fires and production of smog.

When determining the methods of earthwork operations needed, consider the following factors:

- The acreage to be cleared
- The type and density of vegetation
- The physical features of the land
- The expected weather conditions
- The time available for completion of the job

For best results, a combination of methods should be used in a sequence of operations. Use the method most suitable and effective for the job.

EQUIPMENT

Knowing your equipment, its limitations, and its operating characteristics is part of the knowledge you need to know to be an efficient EO on earthmoving jobs.

Equipment production must be determined so that the correct amount and type of equipment is selected for a project. Equipment production rates are available in the *Seabee Planner's and Estimator's Handbook*, NAVFACP-405. The handbook provides information on estimating construction work elements and material quantities, including equipment and manpower requirements.

Before you begin earthmoving operations, it is often necessary to remove overgrowth, boulders, and other obstructions. Also, you often have to build a drainage system, so the construction site will drain. These operations are carried out with bulldozers, scrapers, graders, and similar equipment.

The load, hauled by a scraper, is usually referred to as either **heaped** or **struck** (fig. 15-63). When moving earth, take a full, heaped load and make it

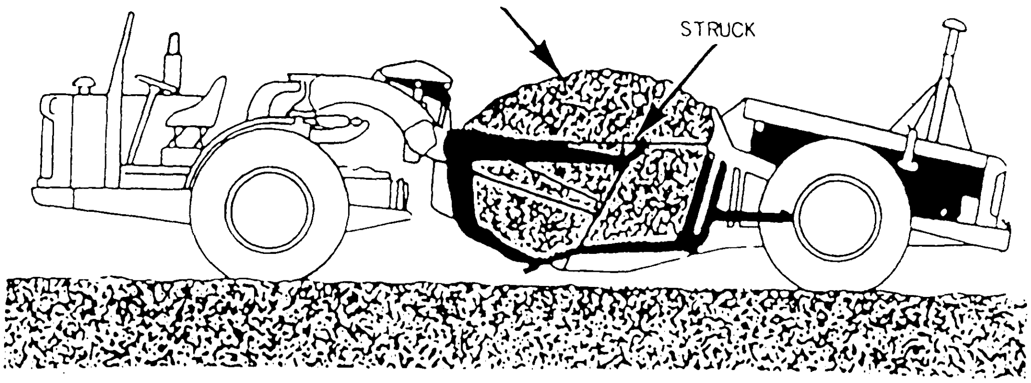


Figure 15-63.-Heaped and struck load.

count. In earthmoving operations, travel can be time-consuming. Suppose you are operating a 12-cubic-yard scraper. It will carry about a 15-cubic-yard heaped load. If you carry only a struck (level) load of 12 cubic yards, you lose 3 cubic yards of load each trip. To move 60 cubic yards takes five trips when only 12 cubic yards are hauled each time. Hauling full, heaped loads, you would move the same amount of material in four trips. If your haul is short and units are waiting to go into the cut, you can increase production by taking only a good load (somewhere between struck and heaped) and moving out, rather than spending extra time obtaining a heaped load.

On most construction jobs, both cuts and fills are required. To increase job efficiency, plan your job so that the material taken from a cut is used in a fill area. This is known as **balancing the material.**

PIONEERING

Pioneering refers to the first working over of an area that is overgrown or rough and making that area accessible for the equipment needed for the project.

In pioneering, the operations of clearing, stripping, grading, and drainage are all done practically at the same time, rather than performed as separate operations. A dozer starts out along a predetermined route and leaves a road behind it. This may be a haul road on which trucks and equipment will use in later operations.

Suppose you, as a dozer operator, get the job of cutting a road on the side of a mountain to be used for access to a proposed airstrip or to reach a mountain stream to be developed into a water supply system. Where should you start and how should you proceed? The route your mountain road is to follow will be staked out by a survey party. You should start your road at the highest point possible and let the force of gravity help the dozer.

In clearing on sidehill cuts, brush and trees should be cast far enough to the side of the road so that they will not be covered with the earth. It is even better if you can cast them over the edge with an angle blade of the dozer when the road is cut. When cutting the road, do not watch the grade stake immediately ahead or you will find yourself below grade. Instead, watch the third or fourth stake down.

NOTE: It is better to be above grade and come back and cut down to grade than to be below grade and have to come back and fill.

CLEARING

Clearing is a construction operation consisting of cleaning a designated area of trees, timber, brush, other vegetation, and rubbish; removing surface boulders and other material embedded in the ground; and disposing of all material cleared.

Clearing, grubbing, and stripping are different in every climatic zone, because each has different types of forests and vegetation. The nature of a forest can be determined from records of the principal climatic factors, including precipitation, humidity, temperature, sunlight, and the direction of prevailing winds. The types of forests can be generally classified as temperate, rain, monsoon, or dry, according to the climates in which they exist.

Clearing usually consists of pushing uprooted trees, stumps, and brush in both directions from the center of the area to be cleared. Clearing should be accomplished so that debris (spoil material) is placed in a designated spot with only one handling. In clearing landing strips, for example, it is generally necessary to dispose of material along each side of the strip outside the construction site. If the site permits burning, the haul distance can be reduced by piling brush, stumps, and trees on the site and burning them. Production in this field must be estimated, rather than calculated.

GRUBBING

Grubbing consists of uprooting and removing roots and stumps. In grubbing, stumps that are difficult or impossible to pull out, even with winches, should be burned or blasted. Your supervisor will decide the method. If the stumps are to be removed by blasting, a qualified blaster must be called upon to do the job. If they are to be burned, you may be assigned the task. Green stumps require continuous application of heat before they catch fire. Check with your supervisor about safety measures that should keep the fire from getting out of control if you have to do any stump burning. Remember that it may take as long as 3 or 4 days for a stump to burn out. Keep a check on the burning during this period. If a project has a high priority and time must be saved, stumps will probably be blasted, rather than burned. When stumps have been removed, refill the holes and level the area to prevent the accumulation of water.

STRIPPING

Stripping consists of removing and disposing of objectionable topsoil and sod. It may either follow or be done with clearing and grubbing. Actual earthmoving begins with stripping; surface soil and rocks are removed from the area to be excavated. Deeply embedded rocks and large boulders may have to be blasted before they can be removed.

The material removed by stripping is called **spoil.** Unless otherwise directed, you should dump spoil along the area to be excavated within range of the earthmoving equipment. If the spoil will not be put to use, such as turfing or finishing the shoulder of a road or runway, it should be wasted along the edges of the project, as shown in figure 15-64. Take care not to disturb necessary drainage.

Equipment, commonly used in stripping, consists of a dozer, a scraper, and a grader. As mentioned earlier, the dozer is the most often used when removing trees. Dozers can handle all short-haul excavations (up to 300 feet). For long-haul excavations (over 300 feet), scrapers should be used. A scraper may be used also on fine soils for shallow stripping. A grader is used mainly for shaping and finishing a stripped surface. It is adaptable also for ditching, for sidecasting, and for sloping banks.

DRAINAGE

Drainage is the construction of facilities needed to allow excess surface and subsurface water to flow from the construction site. Properly designed and constructed drainage systems are one of the most important parts of a construction project. Without proper drainage, rainwater and water running off the surrounding ground could turn the area into a lake. It is also necessary to drain off surface water that would soak down and wet the subgrade.

The elements, determining drainage needs for a road or project site, are the amount of annual rainfall in the area and the routes or areas that can be used to collect or channel excess surface and subsurface water, such as lakes, ponds, streams, or voids (i.e., gullies).

The type of soil is critical to the design and construction of a road. It is poor judgment to construct a road over or through clay, sand, or other undesirable material if it cannot be properly compacted. It is best to bypass this type of material.

If a road surface is to endure continued use for years, it must have firm support from the subgrade. All organic materials, such as living or decayed vegetation, should be removed from the area of the subgrade unless the road is for emergencies or is temporary (detour or military road). In designing and building a road, consider the type of drainage, the type of soil, and the amount of clearing or grubbing necessary.

To facilitate drainage, excavate diversion ditches to conduct all surface water into natural channels or outfall ditches. **Outfall ditches** are constructed to drain low or boggy spots. At the point or the end of the system when the accumulated runoff discharges into the disposal point, the runoff is technically known as **discharge.** The discharge point in the system is called the **outfall.** This preliminary work is done at the same time the area is cleared and grubbed.

The finished drainage system usually consists of ground slopes, ditches, culverts, gutters, storm drains, and underground water drains. Open channels should

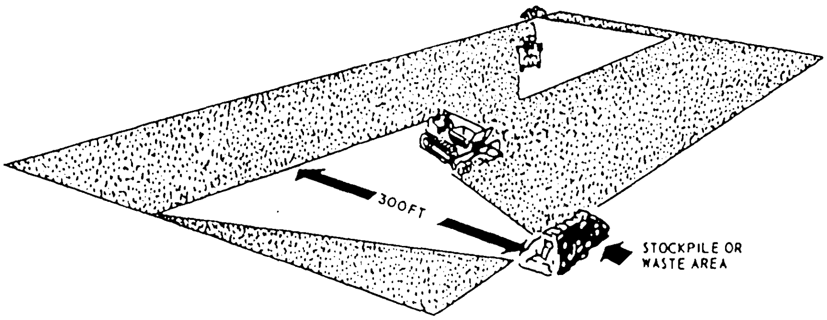


Figure15-64.-Stripping.

be used to intercept or control surface water. These should be dug by bulldozers, scrapers, backhoes, or motor graders, depending on circumstances. Culverts are constructed to drain water across a construction site. Subdrains to drain groundwater are usually excavated with ditchers or backhoes. The drains used are **french drains** (perforated or open-joint tile pipes). Figure 15-65 shows typical covered and french drains.

Runoff water from rain or melted snow is removed from the area by constructing an adequate transverse slope or crown. This runoff is collected in ditches and drained into the nearest natural drainage channel. Drainage for construction sites can be provided by building the ends of the site sloping towards the middle or sloping from one end to the other. These types of drainage construction are shown on the runways in figure 15-66.

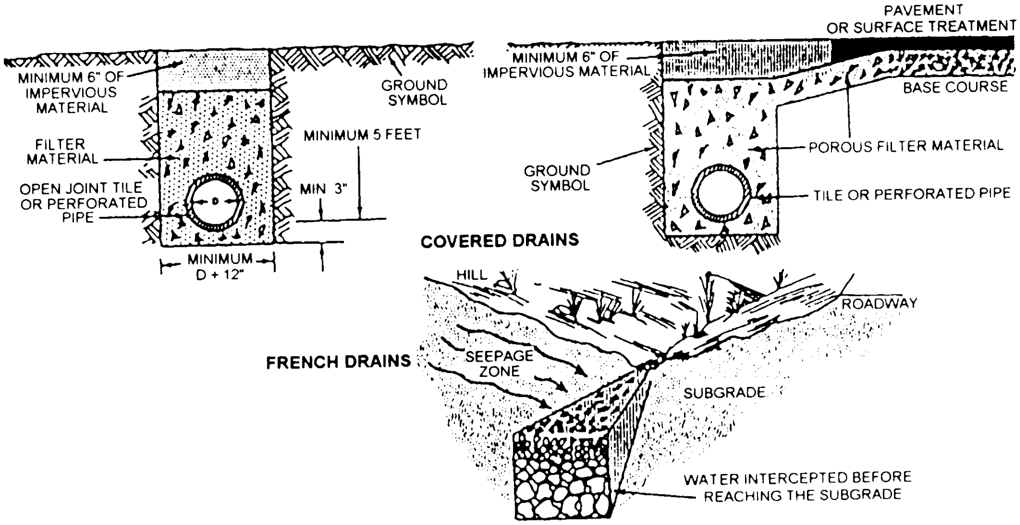

MINIMUM 6" OF IMPERVIOUS MATERIAL
FILTER MATERIAL
OPEN JOINT TILE OR PERFORATED PIPE
D
MINIMUM D + 12"
GROUND SYMBOL
MINIMUM 5 FEET
MIN 3"
PAVEMENT OR SURFACE TREATMENT
MINIMUM 6" OF IMPERVIOUS MATERIAL
BASE COURSE
GROUND SYMBOL
POROUS FILTER MATERIAL
TILE OR PERFORATED PIPE
COVERED DRAINS
HILL
ROADWAY
FRENCH DRAINS
SEEPAGE ZONE
SUBGRADE
WATER INTERCEPTED BEFORE REACHING THE SUBGRADE

Figure 15-65.—Typical sections of covered and french drains.

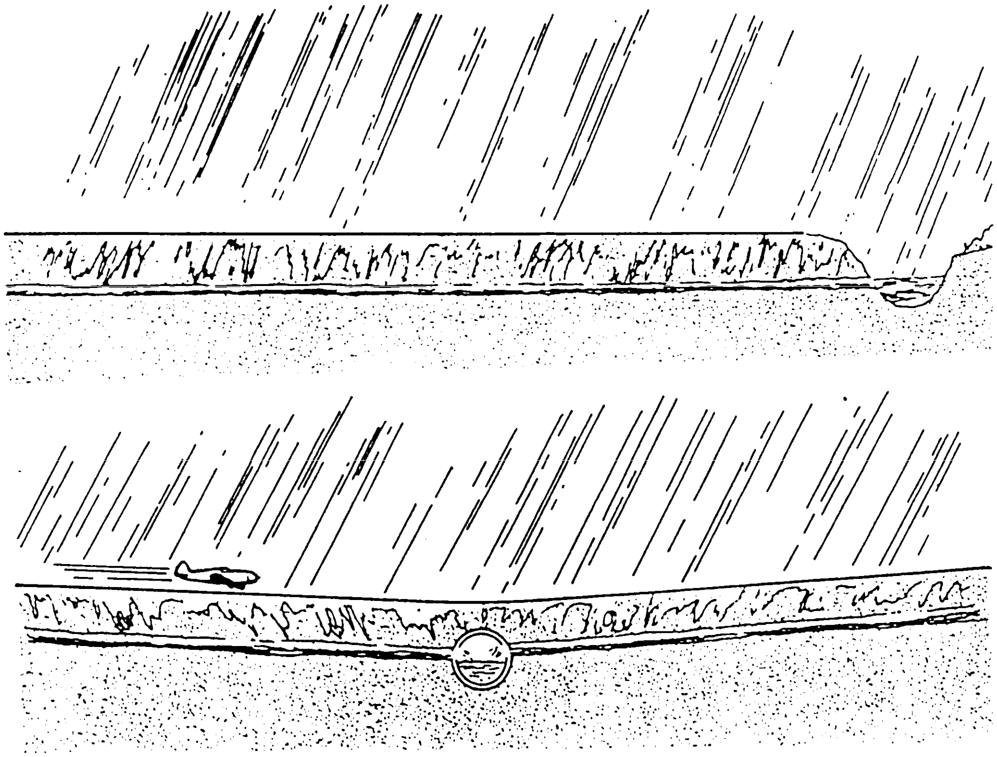


Figure 15-66.—Longitudinal drainage of runways.

GRADING AND EXCAVATING

Grading and excavating are cutting the high spots to grade and filling in the low spots. In cutting down the high spots, enough suitable fill material may be removed to fill in low spots. However, it may be necessary to develop other sources of fill material. If the site is on hard and rocky terrain, loosen and break the soil with a dozer ripper. Before fill material can be placed in low spots, a suitable foundation must be prepared. Material of a low-bearing capacity may have to be dug up before the fill is placed.

Base Course

The base course distributes wheel load stresses from the surface pavement to the subgrade. Since stresses in the base course are more concentrated than in the subgrade, the base course must be stronger.

Placement and Compaction

When placing and spreading base course materials on a prepared subgrade, start at the point nearest the source or at the point farthest from the source. Then place the material progressively away from or toward the source, respectively. The advantage of working from the point nearest the source is that hauling equipment can be routed over the spread material, which helps compact the base course and avoids cutting up the subgrade. An advantage of working from the point farthest from the source is that the hauling equipment further compacts the subgrade, reveals any weak spots in the subgrade, and interferes less with the movement of spreading and compaction equipment.

Base course compaction must produce a uniformly dense layer, conforming in every way to specification requirements. The thickness of the lifts should NOT exceed that which can be compacted to the required density. The thickness of the lifts is determined by the size of the compaction equipment, such as 6 inches for rollers and 3 inches or less when using tampers.

NOTE: Optimum moisture content must be maintained during compaction.

CHAPTER 16

PAVING OPERATIONS AND EQUIPMENT

The modern use of asphalt for road and street construction began in the late 1800s and grew rapidly with the emerging automobile industry. Today, asphalt technology is complex, and the equipment and techniques, used to build asphalt pavement structures, are highly sophisticated. This chapter presents only the basic components, procedures, and principles of paving operations. The extensive knowledge and skills, required to perform the operations, must be gained through formal training and on-the-job-training experience.

NOTE: One rule that has remained constant throughout the long history of the use of asphalt in construction is this: a pavement is only as good as the materials and workmanship that go into it. No amount of sophisticated equipment can make up for the use of poor materials or poor construction practices.

PAVEMENT CONSTRUCTION

Modern paving is broadly divided into **rigid paving** and **flexible paving.** Both types consist of an aggregate blend (sand, gravel, crushed stone, etc.), bound together by a hardening or setting agent, called a **binder.** The primary difference between the two types of paving, from the standpoint of ingredients used, lies in the character of the binder.

The binder for most rigid paving is **portland cement,** and for this reason, rigid paving is often referred to as **concrete paving.** In flexible paving, the binder consists of bituminous material. Paving mixes, containing bituminous material, are referred to as **asphalt-paving mixes.**

ASPHALT-PAVING MIXES

Asphalt-paving mixes may be produced from a wide range of aggregate combinations, with each combination having its own characteristics and being suited to specific design and construction uses. Aside from the asphalt content, the principal characteristics of the mix are determined by the relative amounts of aggregates. The aggregate composition may vary from a coarse-textured mix to a fine-textured mix, depending on aggregate size and design specifications.

The selection of bituminous material depends upon the type of pavement, temperature extreme, rainfall, type and volume of traffic, and type and availability of equipment. In general, hard penetration grades of asphalt paving are used in warm climates and softer penetration grades in cold climates. Heavier grades of asphalt cutbacks and tars are generally used in warm regions.

Asphalt materials are produced by the refining of petroleum (fig. 16-1). Asphalt is produced in a variety of types and grades, ranging from hard, brittle solids to almost water-thin liquids. The semisolid form, known as **asphalt cement,** is the basic material.

Liquid asphaltic products are generally prepared by cutting back (blending) asphalt cements with petroleum distillates or by blending with an emulsified agent and water known as *asphalt emulsion.* Types of liquid asphaltic products are shown in figure 16-2.

Table 16-1 indicates various uses of asphalt for different types of construction.

BASIC CONCEPTS

The basic idea in building roads, airfields, or parking areas for all-weather use by vehicles is to prepare a suitable foundation, to provide necessary drainage, and to construct a pavement that has the following characteristics:

1. Has sufficient total thickness and internal strength to carry expected traffic loads.
2. Is capable of preventing both the penetration and accumulation of moisture.
3. Has a top surface that is smooth and skid resistant.
4. Is resistant to wear and distortion.
5. Is resistant to deterioration caused by weather conditions or by deicing chemicals.

The foundation ultimately carries all traffic loads. Therefore, the structural function of pavement is to support a wheel load on the pavement surface and to transfer and spread that load to the foundation without

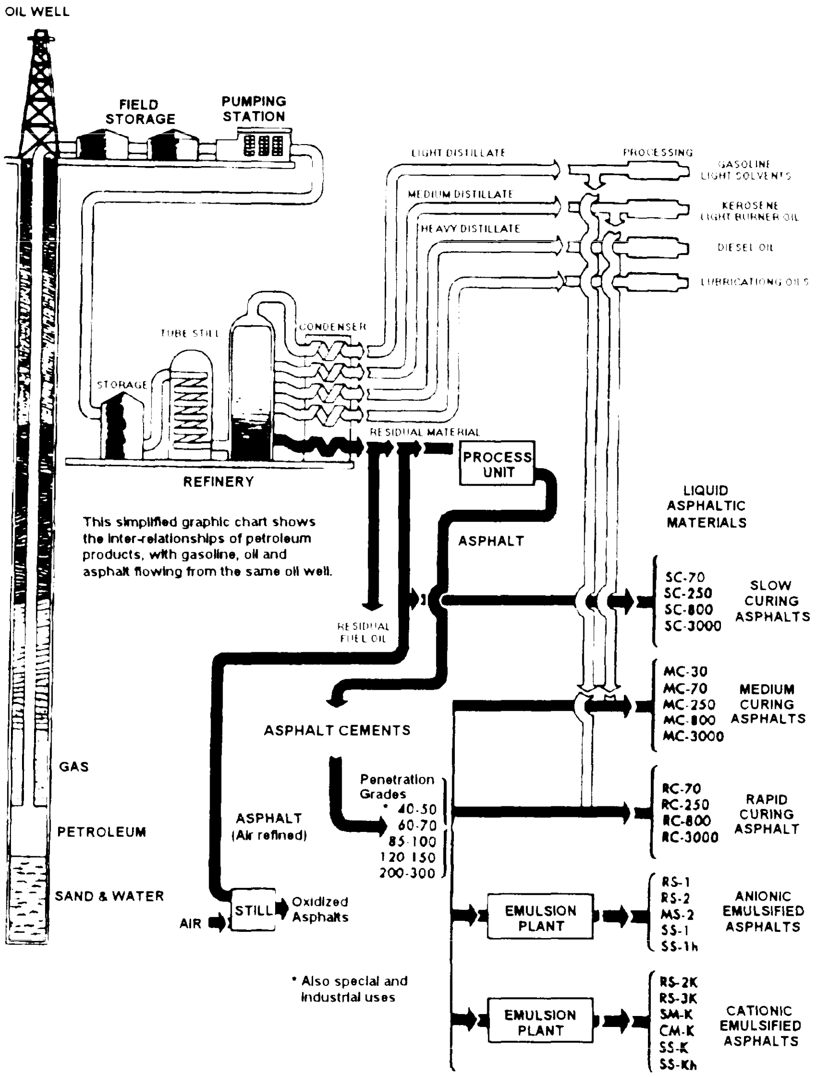
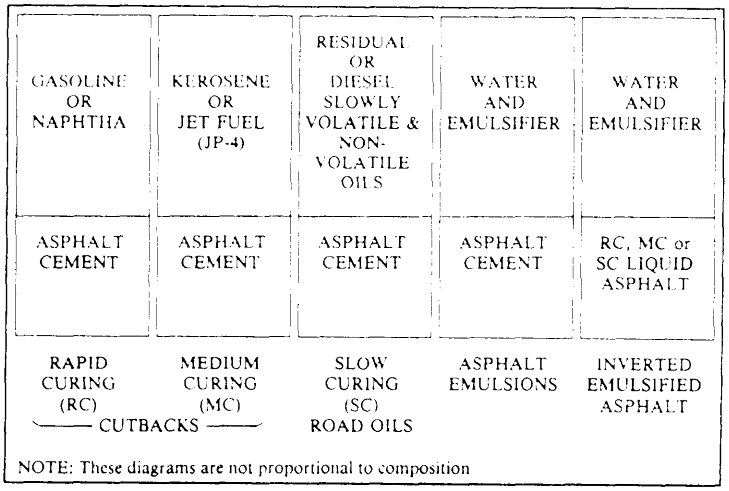

OIL WELL
FIELD STORAGE
PUMPING STATION
LIGHT DISTILLATE
PROCESSING
GASOLINE
LIGHT SOLVENTS
MEDIUM DISTILLATE
KEROSENE
LIGHT BURNER OIL
HEAVY DISTILLATE
DIESEL OIL
LUBRICATING OILS
TUBE STILL
CONDENSER
STORAGE
RESIDUAL MATERIAL
PROCESS UNIT
REFINERY
LIQUID ASPHALTIC MATERIALS
This simplified graphic chart shows the inter-relationships of petroleum products, with gasoline, oil and asphalt flowing from the same oil well.
ASPHALT
RESIDUAL FUEL OIL
SC-70
SC-250
SC-800
SC-3000
SLOW CURING ASPHALTS
MC-30
MC-70
MC-250
MC-800
MC-3000
MEDIUM CURING ASPHALTS
ASPHALT CEMENTS
GAS
Penetration Grades
* 40-50
60-70
85-100
120-150
200-300
ASPHALT (Air refined)
RC-70
RC-250
RC-800
RC-3000
RAPID CURING ASPHALT
PETROLEUM
SAND & WATER
AIR
STILL
Oxidized Asphalts
EMULSION PLANT
RS-1
RS-2
MS-2
SS-1
SS-1h
ANIONIC EMULSIFIED ASPHALTS
* Also special and industrial uses
EMULSION PLANT
RS-2K
RS-3K
SM-K
CM-K
SS-K
SS-Kh
CATIONIC EMULSIFIED ASPHALTS

Figure 16-1.—Petroleum asphalt flow chart.



GASOLINE OR NAPHTHA	KEROSENE OR JET FUEL (JP-4)	RESIDUAL OR DIESEL SLOWLY VOLATILE & NON-VOLATILE OILS	WATER AND EMULSIFIER	WATER AND EMULSIFIER
ASPHALT CEMENT	ASPHALT CEMENT	ASPHALT CEMENT	ASPHALT CEMENT	RC, MC or SC LIQUID ASPHALT
RAPID CURING (RC)	MEDIUM CURING (MC)	SLOW CURING (SC) ROAD OILS	ASPHALT EMULSIONS	INVERTED EMULSIFIED ASPHALT

—— CUTBACKS ——

NOTE: These diagrams are not proportional to composition

Figure 16-2.-Liquid asphaltic products.

overloading either the strength of the subgrade or the internal strength of the pavement itself.

Figure 16-3 shows the wheel load (W) being transmitted to the pavement surface through the tire at an approximately uniform vertical pressure (P405). The pavement then spreads the wheel load to the foundation, so the maximum pressure on the foundation is only P415. By proper selection of pavement materials and with adequate pavement thickness, P415 will be small enough to be easily supported by the subgrade.

ASPHALT PAVEMENT STRUCTURE

Asphalt pavement is a general term applied to any pavement that has a surface, constructed with asphalt (fig. 16-4). Normally, it consists of a surface course (layer) of mineral aggregate, coated and cemented with

Table 16-1.—Recommended Uses of Various Asphalt Grades

TYPE OF CONSTRUCTION	PAVING ASPHALTS					LIQUID ASPHALTS																							
						Rapid Curing (RC)				Medium Curing (MC)					Slow Curing (SC)				Emulsified										
																			Anionic					Cationic					
	40-50	60-70	85-100	120-150	200-300	70	250	800	3000	30	70	250	800	3000	70	250	800	3000	RS-1	RS-2	MS-2	SS-1	SS-1h	RS-2K	RS-3K	SM-K	CM-K	SS-K	SS-Kh
ASPHALT CONCRETE AND PLANT MIX, HOT LAID																													
Highways		x	x	x										x				x											
Airports		x	x																										
Parking Areas		x	x																										
Driveways		x	x																										
Curbs		x	x[1]																										
Industrial Floors	x																												
Blocks	x																												
PLANT MIX, COLD LAID																													
Graded Aggregate													x				x					x						x	x
ROAD MIX																													
Open-graded Aggregate							x	x					x	x							x						x		
Dense-graded Aggregate							x	x				x	x			x	x				x	x				x		x	
Clean Sand							x	x				x	x										x					x	x
Sandy Soil						x	x	x				x	x			x	x					x				x		x	x
PENETRATION MACADAM																													
Large Voids			x					x	x											x					x				
Small Voids				x			x												x					x					
SURFACE TREATMENTS																													
Single, Multiple and Aggregate Seal				x	x		x	x	x			x	x	x					x	x		x		x	x			x	
Sand Seal							x	x				x	x						x			x	x	x				x	x
Slurry Seal																						x	x					x	x
Fog Seal																						x[2]	x[2]					x[2]	x[2]
Prime Coat, open surfaces							x					x																	
Prime Coat, tight surfaces						x				x	x				x														
Tack Coat						x													x			x[2]	x[2]	x				x[2]	x[2]
Dust Laying										x	x				x							x[2]						x[2]	
PATCHING MIX																													
Immediate Use												x					x												
Stock Pile												x	x			x	x									x	x		
HYDRAULIC STRUCTURES																													
Membrane Linings, Canals & Reservoirs	x[3]																												
Hot Laid, Graded Aggregate Mix for Groins, Dam Facings, Canal & Reservoir Linings	x	x																											
CRACK FILLING						x													x			x[4]	x[4]	x				x[4]	x[4]
MEMBRANE ENVELOPE	x	x																											
EXPANSION JOINTS	Blown asphalts, mineral-filled asphalt cements, and preformed joint compositions																												
UNDERSEALING PCC	Blown asphalts																												
ROOFING	Blown asphalts																												
MISCELLANEOUS	Specially prepared asphalts for pipe coatings, battery boxes, automobile undersealing, electrical wire coating, insulation, tires, paints, asphalt tile, wall board, paper sizing, waterproofing, floor mats, ice cream sacks, adhesives, phonograph records, tree grafting compounds, grouting mixtures, etc.																												

In northern areas where rate of curing is slower, a shift from MC to RC or from SC to MC may be desirable. For very warm climates, a shift to next heavier grade may be warranted.

1 In combination with powdered asphalt.

2 Diluted with water.

3 Also 50-60 penetration blown asphalt and prefabricated panels.

4 Slurry mix.

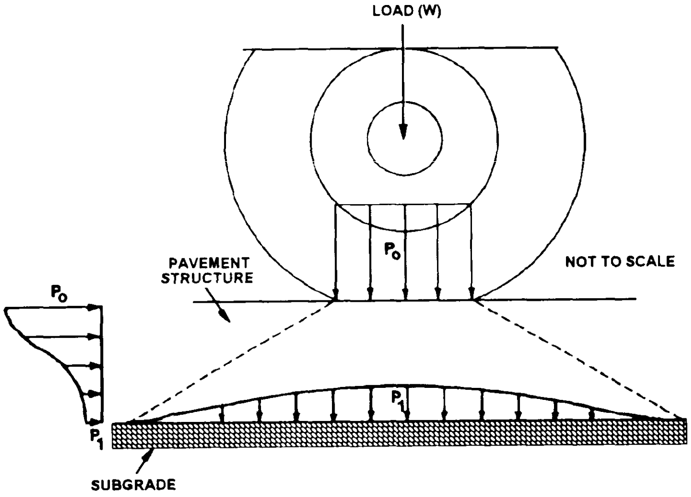


Figure 16-3.-Spread of wheel load through the pavement structure.

asphalt, and one or more supporting courses, which may be of the following types:

1. Asphalt base, consisting of asphalt-aggregate mixtures (macadam)
2. Crushed stone (rock), slag, or gravel
3. Portland cement concrete
4. Old brick or stone block pavements

Asphalt pavement structure consists of all courses above the prepared foundation. The upper or top layer is the asphalt-wearing surface.

Essential Properties of Asphalt-Wearing Surface

The surface of an asphalt pavement, exposed to vehicular traffic, must be tough to resist distortion and to provide a smooth riding surface. It must be waterproof and sloped to shed surface water to the roadside and protect the entire asphalt pavement structure and the foundation from the erosive effects of moisture. It must resist wear, caused by traffic, and still retain necessary anti-skid properties. It must also be bonded to the layer or course beneath it.

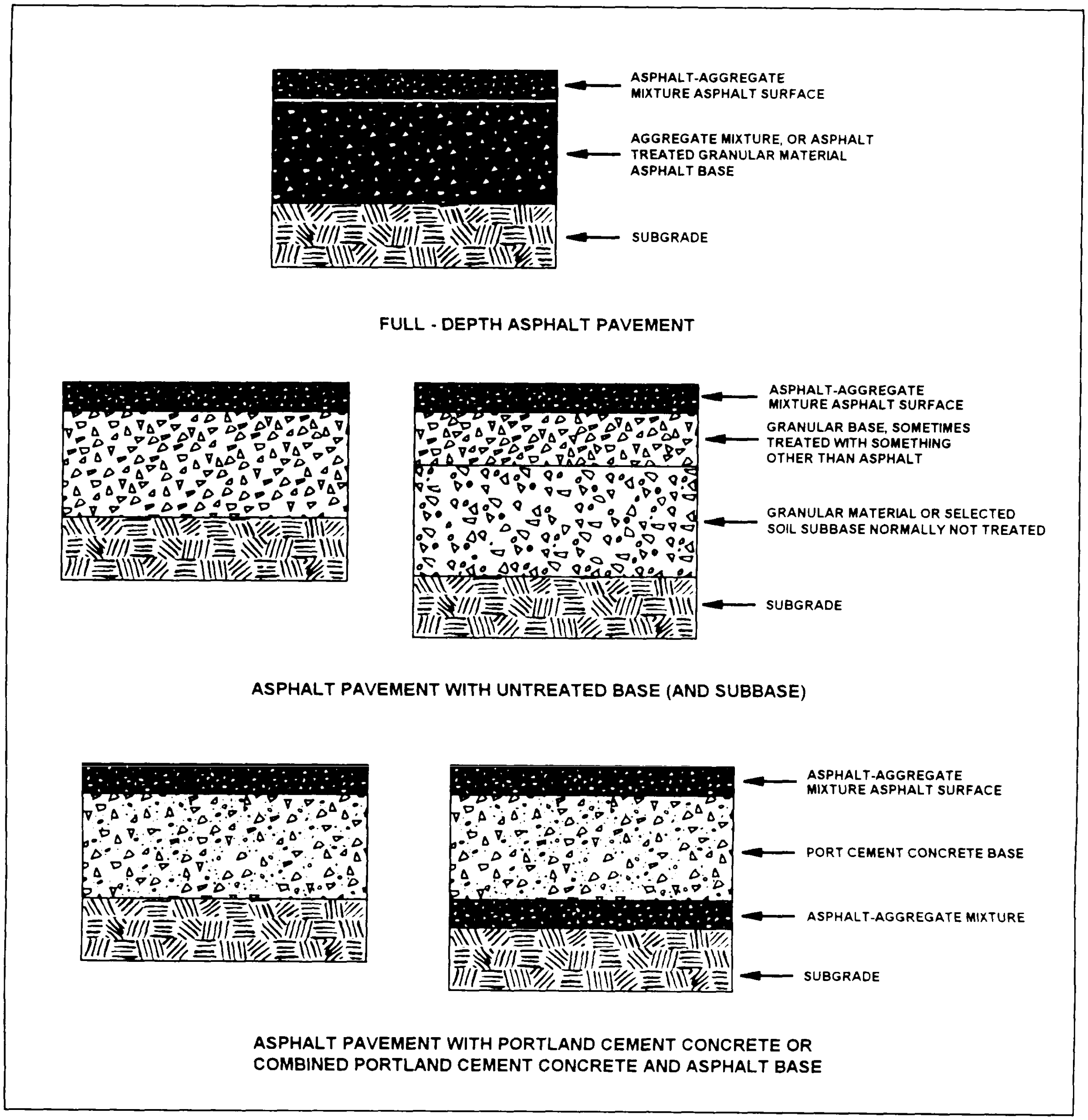

ASPHALT-AGGREGATE MIXTURE ASPHALT SURFACE
AGGREGATE MIXTURE, OR ASPHALT TREATED GRANULAR MATERIAL ASPHALT BASE
SUBGRADE
FULL - DEPTH ASPHALT PAVEMENT
ASPHALT-AGGREGATE MIXTURE ASPHALT SURFACE
GRANULAR BASE, SOMETIMES TREATED WITH SOMETHING OTHER THAN ASPHALT
GRANULAR MATERIAL OR SELECTED SOIL SUBBASE NORMALLY NOT TREATED
SUBGRADE
ASPHALT PAVEMENT WITH UNTREATED BASE (AND SUBBASE)
ASPHALT-AGGREGATE MIXTURE ASPHALT SURFACE
PORT CEMENT CONCRETE BASE
ASPHALT-AGGREGATE MIXTURE
SUBGRADE
ASPHALT PAVEMENT WITH PORTLAND CEMENT CONCRETE OR COMBINED PORTLAND CEMENT CONCRETE AND ASPHALT BASE

Figure16-4.-Asphalt pavement cross sections, showing common and typical asphalt pavement structures.

Function of Base Course and Subgrade

The base course and subgrade are structural elements of the pavement. In conjunction with the overlying asphalt surface, their purpose is to distribute traffic wheel loads over the whole foundation (fig. 16-4). To perform this function, you build the base course and subgrade with the necessary internal strength properties. In this respect, full-depth asphalt pavements have a special advantage over pavements with granular bases.

Asphalt pavement layers have both tensile and compressive strength to resist internal stresses. For example, figure 16-5 shows how wheel load (W) slightly deflects the pavement structure, causing both tensile and compressive stresses within the pavement. Untreated granular bases have no tensile strength; therefore, asphalt bases spread the wheel load over broader areas than untreated granular bases. The result of this is that less total pavement structure thickness is required for an asphalt base.

Determining Required Pavement Thickness

A significant advance in highway engineering is the realization and demonstration that structural design of

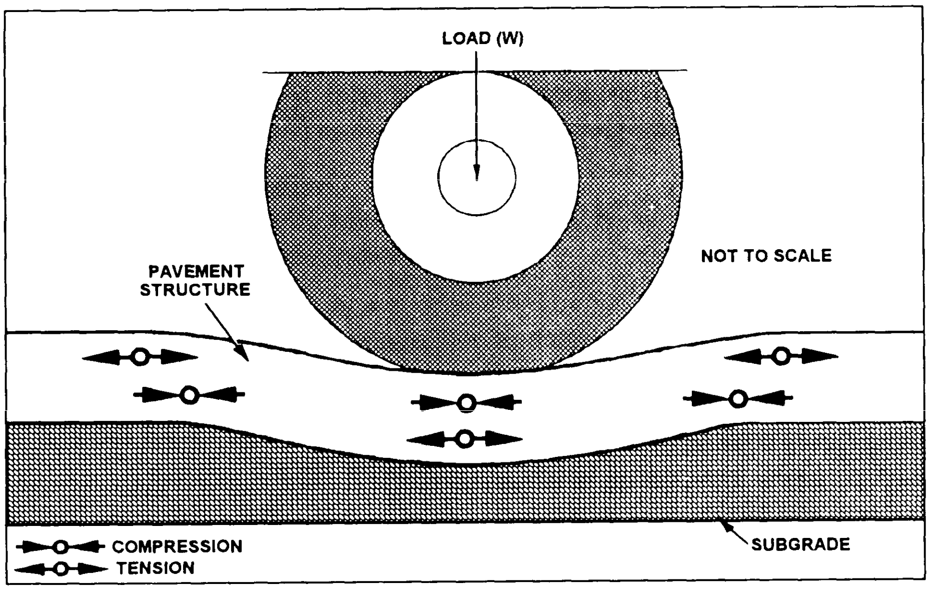


Figure 16-5.—Pavement deflection results in tensile and compressive stresses in pavement structure.

asphalt pavements is similar to the problem of designing any other complex engineering structure. When asphalt pavement was first being introduced, determining the proper thickness was a matter of guesswork, rule of thumb, and opinion, based on experience. Almost the same situation once prevailed in determining the dimensions of masonry arches and iron and steel structures. However, these early techniques have long since yielded to engineering analysis. Similarly, based on comprehensive analysis of vast volumes of accumulated data, the structural design of asphalt pavements has now been developed into a reliable engineering procedure.

There is no standard thickness for a pavement. Required total thickness is determined by engineering design procedure. Factors considered in the procedure are as follows:

1. Traffic to be served initially and over the design service life of the pavement

2. Strength and other pertinent properties of the prepared subgrade

3. Strength and other influencing characteristics of the materials available or chosen for the layers (or courses) in the total asphalt pavement structure

4. Any special factors peculiar to the road being designed

Stage Construction

Because weight and traffic volume normally increase, pavement originally built thick enough to handle immediate traffic volumes may not be thick enough and strong enough to handle future needs. With asphalt pavement, this problem can be met economically by first building the thickness required, then adding, when needed, layers of asphalt to increase total pavement thickness. This procedure is called **stage construction.** It avoids excessive investment in the beginning; and when a new layer of asphalt is added, the wearing surface is equal to or better than the original.

Subgrade Evaluation

Several methods for evaluating or estimating the strength and supporting power of a subgrade are in use today, including the following:

1. Loading tests in the field on the subgrade itself. For example, the plate bearing test uses large, circular plates, loaded to produce critical amounts of deformation on the subgrade in place.

2. Loading tests in a laboratory using representative samples of the subgrade soil. A test commonly used by the Seabees is the California bearing ratio (CBR) test, which is sometimes used on the subgrade in place in the field.

3. Evaluations, based on classification of soil by identifying and testing the constituent particles of the soil.

Two well-known classification systems are the American Association of State Highway and Transportation Officials (AASHTO) Classification System and the Unified Soil Classification System, used by the Department of Defense.

PREPARING ASPHALT FOR CONSTRUCTION OPERATIONS

Paving grade asphalt (asphalt cement), which at normal atmospheric temperatures is semisolid and highly viscous, must be made temporarily fluid (liquefied) for handling during construction operations, such as pumping through pipes, transporting in tanks, spraying through nozzles, and mixing with aggregate. When pavement construction operations are finished, the asphalt cement reverts to its normal condition and functions as the cementing (or binding) and waterproofing agent that makes the pavement stable and durable.

Asphalt cement can be made temporarily fluid (liquefied) for construction operations in three ways:

1. By heating the asphalt. After construction operations, the hot liquid asphalt cement cools and changes from a fluid to its normal, semisolid condition.

2. By dissolving the asphalt in selected petroleum solvents. This process is called **cutting back;** the diluted asphalt is called **cutback asphalt.** After construction the solvent evaporates, leaving the asphalt cement in place.

NOTE: The use of cutback asphalt in the United States has declined because of the petroleum shortage and government environmental regulations. It is being superseded by emulsified asphalt, which contains little or no solvent, and can be used for almost any purpose that cutbacks can.

3. By emulsifying the asphalt with an emulsifying agent and water. While asphalt and water ordinarily do not mix, they can be made to mix by churning asphalt in a **colloid mill.** The resulting product, called **emulsified asphalt,** is a fluid and is ready for construction operations. During construction the water and asphalt separate. The asphalt particles merge into a continuous film that cements the aggregate particles together as the water evaporates. When the water and asphalt separate, it is said that the emulsion **breaks** or **sets.**

A hot-mixed or hot-load paving mixture is the best type of pavement; the aggregate and binder should be heated to approximately 310°F and laid no colder than 250°F. Determining the exact temperature(s) to use will depend upon the weather and the distance that the material is hauled. Some clues that indicate the condition of the asphalt are as follows:

- Overheated asphalt loses some of its binding qualities. Blue smoke, rising from the spreader hopper, is sometimes an indicator this condition exists.

- A generally stiff appearance and improper coating of aggregate indicates the mix is too cold.

- Material laying flat in the bed of the truck with a shiny appearance means the mix is too rich in asphalt cement.

- When it is too lean, the mix will look dry and dull.

Prime Coat

Priming consists of the initial treatment on a granular base before surfacing with a bituminous material or pavement. The purpose of a prime coat is to penetrate the base (about 1/4-inch minimum penetration is desired), fill most of the voids, promote adhesion between the base and the bituminous applications placed on top of it, and waterproof the base. Surfaces must be as clean as possible, and where and conditions exist (dried-out surfaces), a light fog spray with water should be considered before priming actually begins.

The priming material may be either a low-viscosity tar, a low-viscosity asphalt, or a diluted asphalt emulsion. The bituminous materials, used for the prime coat, should be applied in quantities known as **rate of application (ROA)** of not less than 0.2 gallon or more than 0.5 gallon per square yard. Normally, the construction project specifications denote the ROA for the prime coat application; however, when the ROA is not included in the project specifications, the NCF uses an ROA of .3 for planning purposes. When the base absorbs all of the prime material within 1 to 3 hours or when penetration is too shallow, the base is underpriced. Underpriming may be corrected by applying a second coating of the prime material.

An overprimed base may fail to cure or set and may contribute to failure of the pavement or bleed up through the asphalt mat. A free film of prime material remaining on the base after a 45-hour curing period indicates that the base is overpriced. This condition may be corrected by spreading a light, uniform layer of clean, dry sand over the prime coat to absorb the excess material. Application of the sand is usually followed by light rolling and brooming. Excess prime, held in minor depressions, should be corrected by an application of clean, dry sand. Any loose sand should be lightly broomed from the primed surface before the wearing surface is laid.

The primed base should be adequately cured before the wearing surface is laid. In general, a minimum of 48 hours should be allowed for complete curing. Ordinarily, proper surface condition is indicated by a slight change in the shiny black appearance to a slightly brown color.

When a soil base is to be covered by a bituminous wearing surface, the area should be barricaded to prevent traffic from carrying dust or mud onto the surface both before and after priming. If it is necessary to open the primed base course to traffic before it has completely cured, a fine sand may be used; when you are ready to place the wearing surface, lightly broom the sand from the primed base course.

To estimate the amount of bitumen required for the prime coat, multiply the area to be treated by the rate of application (ROA).

NOTE: Under certain conditions, the estimate should include sufficient bitumen for an additional width of 1 foot on each side of the surface course to be constructed on the primed base.

The formula for a prime coat estimate is as follows:

For computing gallons:

Step 1:

$$Gallons\ of\ Prime\ Coat\ Needed = \frac{ROA \times L \times W}{9}$$

Step 2:

Gallons needed for waste

= Gallons of prime coat × WF (.05 or .10)

Step 3:

Total gallons required for the project:

= Gallons of prime coat + waste gallons

Where

ROA = rate of application of bitumen in gallons per square yard

L = length of treated section in feet

W = width of treated surface in feet

9 = square feet per yard conversion factor

WF = Waste factor of bitumen = 5% at .05 or 10% at .10. This will depend on the experience of the asphalt distributor truck crew.

Example: the specification and other data for a prime coat application are as follows:

L = 3 miles = 3 × 5280 = 15840 feet

W = 12 feet + 1 foot on each side of the surface course to be constructed on the primed base

ROA = 0.3 gal/sq yd

WF = 5% or .05

Calculate the number of gallons of bitumen necessary to spray a tack coat.

Solution:

Step 1:

$$Gallons = \frac{.3 \times 15840 \times 14}{9} = \frac{66528}{9} = 7392 \text{ gallons}$$

Step 2:

Waste = 7392 gallons × WF of .05 = 369.6 gallons

Step 3:

Total gallons required for the project:

369.6 gallons + 7392 gallons = 7761.6 gallons

Always round your answer to the next higher number. In this case, 7761.6 is rounded to 7762 gallons.

Tack Coat

A tack coat is an application of asphalt to an existing paved surface to provide bond between the existing surface and the asphalt material to be placed on it. Two essential requirements of a tack coat areas follows: (1) it must be thin and (2) it must uniformly cover the entire surface to be treated. A thin tack coat does no harm to the pavement, and it will properly bond the course.

Some of the bituminous materials, used for tack coats, are rapid-curing cutbacks, road tar cutbacks, rapid-setting emulsions (may be used in warm weather), and medium-asphalt cements. Because rapid-curing cutbacks are highly flammable, safety precautions must be carefully followed.

A tack coat should be applied only when the surface to be tacked is dry; and the atmospheric temperature has not been below 35°F for 12 hours immediately before application.

Before applying the tack coat to a surface that is sufficiently bonded, ensure that all loose material, dirt, clay, or other objectionable materials are removed from the surface to be treated. This operation may be accomplished with a power broom or blower, supplemented with hand brooms if necessary.

Immediately following the preparation of the surface, the bituminous material should be uniformly applied by means of a bituminous (asphalt) distributor at the spraying temperature specified. The amount of bitumen application, known as **rate of application (ROA),** for a tack coat should be applied in quantities not less than 0.05 or more than 0.25 gallon per square yard. The exact quantity varies with the condition of the existing pavement being tack-coated. Normally, the construction project specification denotes the ROA for the tack coat application; however, when the ROA is not included in the project specifications, the NCF uses an ROA of .15 for planning and estimating purposes.

Following the application of bituminous material, the surface should be allowed to dry until it is in a proper condition of tackiness to receive the surface course; otherwise, the volatile substances may act as a lubricant and prevent bonding with the wearing surface. Clean, dry sand should be spread on all areas that show an excess of bitumen to blot up and cure the excess effectively. After excess bitumen is set, any loose sand should be lightly broomed from the primed surface before the wearing surface is laid.

An existing surface that is to be covered by a bituminous wearing surface should be barricaded to prevent traffic from carrying dust or mud onto the surface, either before or after the tack coat is applied. Should it become necessary for traffic to use the surface, one lane may be tack-coated and paved, using the other lane as a traffic bypass. The bypass lane should be primed and sanded before it is opened to traffic and it should be swept and reprimed after the adjacent lane is completed. Doing this preserves the base and acts as a dust palliative (shelter.)

The formula for a tack coat estimate is as follows:

For computing gallons:

Step 1:

$$Gallons\ of\ Tack\ Coat\ Needed = \frac{ROA \times L \times W}{9}$$

Step 2:

Gallons needed for waste

= Gallons of tack coat × WF (.05 or .10)

Step 3:

Total gallons required for the project:

= Gallons of tack coat + waste gallons

Where

ROA = rate of application of bitumen in gallons per square yard

L = length of treated section in feet

W = width of treated surface in feet

9 = square feet per yard conversion factor

WF = Waste Factor of bitumen = 5% at .05 or 10% at .10. This will depend on the experience of the asphalt distributor truck crew.

Example: The specification and other data for a tack coat application are as follows:

L = 2 miles= 2 x 5280= 10560 feet

W = 12 feet

ROA = *0.5* gal/sq yd

WF = *5%* or .05

Calculate the number of gallons of bitumen necessary to spray a tack coat.

Solution:

Step 1:

$$Gallons = \frac{.05 \times 10560 \times 24}{9} = \frac{12672}{9} = 1408 \text{ gallons}$$

Step 2:

Waste = 1408 gallons × WF of .05 = 70.4 gallons

Step 3:

Total gallons required for the project:

70.4 gallons + 1408 gallons = 1478.4 gallons

Always round your answer to the next higher number. In this case, 1478.4 is rounded to 1479 gallons.

TYPES OF ASPHALT PAVEMENT CONSTRUCTION

Two major types of asphalt pavement construction are in use today: **plant mix construction** (so-called because the mixture is prepared in a central mixing plant) and **mixed-in-place construction** (so-called because the mixture is mixed on the area to be paved).

PLANT MIX CONSTRUCTION

Asphalt-paving mixtures, prepared in a asphalt mixing plant, are known as **plant mixes.** Plant mix asphalt concrete is considered the highest quality plant mix. It consists of well-graded, high-quality aggregate and asphalt cement. The asphalt and aggregate are heated separately from 250°F to 325°F, carefully measured and proportioned, then mixed until the aggregate particles are coated with asphalt. The hot mixture, kept hot during transit, is hauled to the construction site where it is spread on the roadway with an asphalt-paving machine. The smooth layer from the paver is compacted by rollers to proper density before the asphalt cools.

Asphalt concrete is but one of a variety of hot-asphalt plant mixes. Other mixes, such as sand asphalt and coarse-graded mixes, are prepared and placed in a similar manner; however, each has one common ingredient, which is asphalt cement.

Asphalt mixes, containing emulsified or cutback asphalt, may also be prepared in asphalt mixing plants. The aggregate may be partially dried and heated or mixed as it is withdrawn from the stockpile. These mixes are usually refered to as **cold mixes,** even though heated aggregate may have been used in the mixing process.

Both asphalt mixtures, made with emulsified asphalt and some cutback asphalts, can be spread and compacted on the roadway while quite cool. Such mixtures are called **cold-laid asphalt plant mixes** They are hauled and placed in normal warm weather temperatures. These mixtures, after being placed on the roadway, are sometimes processed or worked back and forth laterally with a grader before being spread and compacted. This action speeds up setting or curing.

Compute Plant-Mix Materials

Several methods are used to calculate the amount of hot-mix material, required for paving projects; however, when the weight of a hot mix per square yard or cubic foot is not known, two equations are used in the NCF to compute the number of tons of asphalt, required for a project. These equations are as follows:

Equation 1

$$\textit{Tons of Asphalt} = \frac{L \times W \times D \times 146}{2{,}000} = \textit{Tons} \times (WF)$$

$$= \textit{Percent of Tons} + \textit{Tons} = \textit{Tons Required}$$

L = length of project in feet.

W = width of project in feet.

D = depth or thickness of compacted mat. You must change inches into feet by dividing the number of inches by 12 (inches in 1 foot). For paver screed height, add 1/8 inch for each inch of the mat to be paved. (Example: For a 2-inch mat, two blocks of wood 2 1/4 inches thick will be required to set under the screed.) The blocks must be thicker than the finished compacted mat to allow for additional compaction by rollers.

146 = This number represents the approximate weight of 1 cubic foot of compacted hot-mix asphalt. This number can vary from 140 to 160 pounds; however, 146 pounds equals the 110 pounds per square yard per l-inch depth of asphalt used in the second equation for figuring tons require for asphalt. (See table 16-2.)

WF = Waste factor equals 5% or .05, or 10% or .10, depending on the experience of the screed operators and handwork required on the project.

2,000 = 2,000 pounds is equal to one ton; therefore, you must divide the total weight of material by 2,000, giving tons required.

Equation 2

$$\textit{Tons of Asphalt} = \frac{L \times W}{9} = \textit{Square Yards} \times \frac{110 \textit{ Pounds Per } 1'' \textit{ Mat}}{2{,}000}$$

$$= \textit{Tons} \times \textit{WF} = \textit{Percent of Tons} + \textit{Tons} = \textit{Tons Required}$$

Table 16-2.-Weight and Volume Relations for Various Types of Compacted Asphalt Pavement

Note:	Pounds Per Cubic Foot	Pounds Per Cubic Yard	Pounds Per Square Yard Per 1 inch Depth
Because of the considerable variations of specific gravity, gradation, and other characteristics of mineral aggregates, weight per unit volume of compacted asphalt pavement varies considerably. Exact weights per unit volume should be determined in the laboratory from samples taken from the pavement or prepared in the laboratory with the same materials as used in the field.	100	2700	75
	105	2835	79
	110	2970	83
	115	3105	86
	120	3240	90
	125	3375	94
	130	3510	97
	135	3645	101
	140	3780	105
	145	3915	109
	150	4050	112
	155	4185	116
	160	4320	120

	Range	Range	Range	Frequently Used for Preliminary Estimate
Macadam-A.I. Type I or Penetration Macadam	110-135	2970-3645	82-101	95
Open Graded-A.I. Type II	115-140	3105-3780	86-105	100
Coarse Graded-A.I. Type III	130-150	3510-4050	97-112	105
Dense Graded-A.I. Type IV	135-155	3645-4185	101-116	110
Fine Graded-A.I. Type V	130-150	3510-4050	97-112	105
Stone Sheet-A.I. Type VI	130-150	3510-4050	97-112	105
Sand Sheet-A.I. Type VII	120-140	3240-3780	90-105	100
Fine Sheet-A.I. Type VIII	120-140	3240-3780	90-105	100
Mixed-in-Place Macadam-A.I. Spec. RM-1	110-135	2970-3645	82-101	95
Mixed-in-Place Dense Graded-A.I. Spec. RM-2	110-135	2970-3645	82-101	95
Mixed-in-Place Sand Asphalt-A.I. Spec. RM-3	100-125	2700-3375	75-94	85

Where

L = Length of project in feet.

W = Width of project in feet.

110 = Pounds per square yard of asphalt per 1-inch depth. (Example: A 2-inch mat will equal 220 pounds per square yard.)

9 = To obtain square yards from square feet, divide by 9.

2,000 = 2,000 pounds equal one ton; therefore, you must divide the total weight of material by 2,000, giving tons required.

WF = Waste factor equals 5% or .05, or 10% or .10, depending on the experience of the screed operators and handwork required on the project.

Example: The specifications for a parking lot paving project are as follows:

L = 90 feet

W = 30 feet

D = 2 inches

WF = .10

Find the amount of asphalt required for this project.

Solution:

$$Equation\ 1 = \frac{30\ Feet \times 90\ Feet \times .167 \times 146}{2{,}000} = \frac{65831.4}{2{,}000} = 32.9$$

(32.9 is rounded off to 33)

$$WF = 33 \times .10 = 3.3\quad Total\ Tons\ Required = 3.3 + 33 = 36.3$$

(36.3 is rounded off to 37)

$$Equation\ 2 = \frac{30\ Feet \times 90\ Feet}{9} = 300\ Square\ Yards = \frac{300\ Square\ Yards \times 220}{2{,}000} = 33$$

$$WF = 33 \times .10 = 3.3\quad Total\ Tons\ Required = 33 + 3.3 = 36.3$$

Placing Plant-Mix Materials

The material that arrives at the construction site from the plant must be spread. It must cover the entire width of the road being paved. It is then struck off to the desired shape and thickness and compacted. Three general methods of spreading and shaping the material are in use today: hand spreading, blade spreading, and mechanical spreading.

HAND SPREADING.— Hand spreading is the oldest method used to spread and shape the mixed material. For this method, the mix is dumped from the trucks onto dump boards from which the material is shoveled onto the road or runway. After placement, it is raked smooth to grade and contour and compacted with a roller.

WARNING

Asphalt and bituminous materials contain coal tars, benzene, and other components which are suspected or known carcinogens. Workers should avoid inhalation of the vapors and prolonged skin contact with these materials. Review the Materials Safety Data Sheet (MSDS) for specific hazards and precautions.

Because of the high cost of labor and the inability to obtain a smooth and even-textured surface, hand spreading is not used to any great extent. It is used primarily to supplement the other spreading methods. For example, hand spreading is used effectively for adjacent curbing and around manholes.

When placing the material by hand, you should be extremely careful to prevent segregation of the mix. Do NOT throw the material a long distance and do NOT dump it from too great a height. Dump the material in small piles and level the material with shovels, rakes, and lutes. Use the shovel to move the excess material and the lute and rakes to level it. The material should be as level as possible before compacting it.

BLADE SPREADING.— Blade spreading is done with a grader by a skilled operator. The grader blade can obtain reasonably good surface smoothness. Each successive pass of the grader blade reduces the irregularities in the surface. Often, blade spreading is used in areas too large for hand spreading and inaccessible to mechanical spreading.

MECHANICAL SPREADING.— Specialized machines have been developed to spread bituminous paving materials. Self-propelled, these machines have crawler, wheels, or rollers which run on the base course foundation or surface. The mix from the plant is dumped into a hopper on the front of the paver. The paver places the mix evenly on the road itself. Figure 16-6 shows a bituminous paver that can handle any type of asphaltic mix.

Compacting Plant-Mix Materials

The most important phase of flexible pavement construction is compaction. When the specified density of asphalt pavement mix is not obtained during construction, subsequent traffic will further consolidate the pavement. This consolidation occurs principally in the wheel paths and appears as channels in the pavement surface.

Most mixtures compact quite readily when they are spread and rolled at temperatures that assure proper asphalt viscosity. Rolling should start as soon as possible after the material has been spread by the paver but should be done with care to prevent unduly roughening of the surface.

Mix temperature is a principal factor affecting compaction. Compaction can only occur while the asphalt binder is fluid enough to act as a lubricant. When it cools enough to act as an adhesive, further compaction is extremely difficult to achieve. The best time to roll an asphalt mixture is when its resistance to compaction is the least, while at the same time, it is capable of supporting the roller without excessive shoving of the asphalt material. The best rolling temperature is influenced by the interparticle friction of the aggregates, the gradation of the mix, and the viscosity of the asphalt; therefore, it can change if any of these factors change. The critical mix temperature in

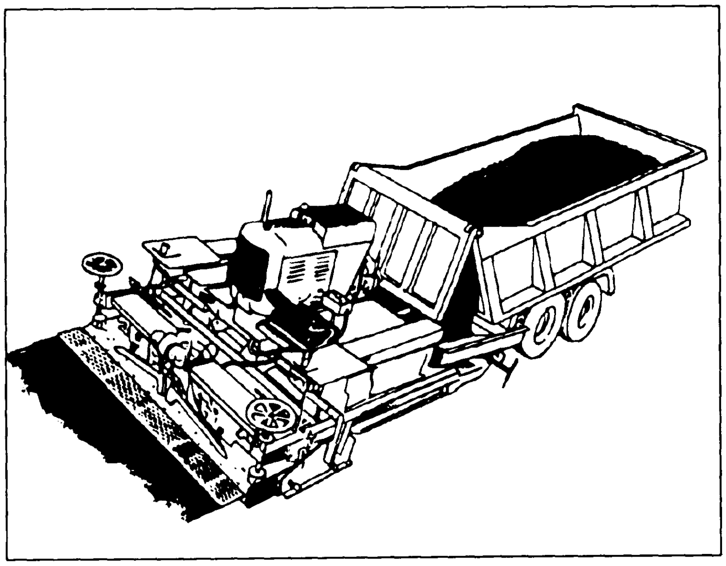


Figure 16-6.-Bituminous paver.

an asphalt-paving project is the temperature at the time of compaction.

During rolling, the roller wheels must be kept moist with only enough water to avoid picking up material. Rollers move at a slow, but uniform, speed with the drive wheels nearest the paver. The speed should not exceed 3 mph for steel-wheeled rollers or 5 mph for pneumatic-tired rollers. A roller must be maintained in good condition, capable of being reversed without backlash. The line of rolling should not be suddenly changed or the direction of rolling suddenly reversed, because these actions will displace the mix. Any pronounced change in direction should be made on stable material.

When rolling causes material displacement, the affected areas should be loosened at once with lutes or rakes and restored to their original grade with loose material before being rerolled. Heavy equipment, including rollers, should not be permitted to stand on the finished surface before it has thoroughly cooled or set.

Rolling freshly placed asphalt mix is done in the following order:

1. Transverse joints
2. Longitudinal joints
3. Breakdown or initial rolling
4. Intermediate or second rolling
5. Finish rolling

The five steps in rolling freshly placed bituminous or asphalt mix are covered in chapter 11 of this TRAMAN.

MIXED-IN-PLACE CONSTRUCTION

Emulsified asphalt and many cutback asphalts (although the use of cutbacks is declining) are fluid enough to be sprayed onto and mixed into aggregate at moderate to warm weather temperatures. When this is done on the area to be paved, it is called **mixed-in-place** construction. Although mixed-in-place is the more general term and is applicable whether the construction is on a roadway, parking area, or airfield, the term *road mix* is often used when construction is on a roadway.

Mixed-in-place construction can be used for surface, base, or subgrade courses. As a surface or wearing course, it usually is satisfactory for light and medium traffic, rather than heavy traffic. However, mixed-in-place layers, covered by a high-quality asphalt plant-mix surface course, make a pavement suitable for heavy traffic service. The advantages of mixed-in-place construction include the following:

1. Utilization of aggregate already on the roadbed or available from nearby sources and usable without extensive processing.

2. Elimination of the need for an asphalt mixing plant. Construction can be accomplished with a variety of machinery often more readily available, such as motor graders, rotary mixer with revolving tines, or traveling mixing plants.

ROAD-MIX PAVEMENTS

Road-mix pavements consist of mineral aggregate and mineral filler uniformly mixed in place with a bituminous material and compacted on a prepared base course or subgrade. A single layer, about 1 1/2 inches to 3 inches thick, is generally used. This type of pavement is likely to become defective unless it has a sound, well-drained subgrade and is well-mixed, uniformly spread, and properly compacted. Road-mix pavements may be used as a wearing surface on temporary roads and airfields and as a bituminous base or binder course in construction of more permanent types of roads and airfields. Road mix is an economical method of surfacing small areas when aggregate can be used from the existing base or when satisfactory aggregate is nearby.

For road-mix pavements, the grade and type of bituminous material depend upon the aggregate and equipment available as well as weather conditions and time required to complete the project. Good weather is important to the success of a road-mix project. Where possible, road-mixing operations should be scheduled when weather conditions are likely to be hot and dry during, and for some time after, the project. Recommended types of bituminous materials suitable for road mix are asphalt cutbacks, asphalt emulsions, and road tars. A medium-curing cutback is generally used in a moderate climate, and a rapid-curing cutback is used in a cold climate. Viscosity required is determined by the temperature, aggregate gradation, and method of mixing. The highest viscosity that will completely and uniformly coat the particles of aggregate should be used. In general, open-graded aggregate requires a high viscosity; a gradation, containing mineral filler, requires a less viscous grade.

Aggregate, used in road mix, may be scarified from the existing subgrade or hauled in from a nearby source. A wide range of coarse and fine aggregate and mineral filler may be used. The ideal aggregate for road-mix pavement is a well-graded (dense or open) sandy gravel or clean sand. Maximum size of the aggregate, in general, is limited to two thirds of the compacted thickness of the layer. Loose thickness is approximately 1 1/4 times the desired compacted thickness.

"Surface moisture" is defined as the film of water around each particle of stone or sand. The amount present is determined by heating a weighed sample of aggregate at 212°F in an open pan and stirring it with a rod until the surface water disappears (3 to 10 minutes). The difference between the original and final weights is considered to be moisture lost during drying. The loss in weight, expressed as a percent of the final or dry weight, is the moisture content, allowed before the aggregate is mixed with asphalt cutbacks or road tars. When the aggregate is too wet, it should be worked with mechanical mixers, graders, or improvised plows to allow the excess moisture to evaporate. For cutbacks and tars, moisture content of coarse-graded aggregate should not exceed 3 percent, and of fine-graded aggregate, 2 percent. For emulsions, moisture content of coarse-graded aggregate should not exceed 5 percent, and of fine-graded aggregate, 3 percent.

The quality of the road-mix pavement depends largely upon the control of the mix. The percentage of bitumen will vary in relation to the absorptive quality of the aggregate, rate of evaporation of the volatile substances, and other factors. Although an exact formula is difficult to follow, proportioning must be controlled within narrow limits to assure the stability and life of the mix. With dense-graded aggregates especially, too much bitumen should not be used. All particles of the completed mix should be coated and uniform in color. When the mix is too lean, the aggregate in the windrow will stand almost vertically and have a dull look; and when the mix is too rich, it will ooze or slip out of shape. When the mix is correctly proportioned, a handful, squeezed into a ball, will retain its shape when the hand is opened.

Road-mix pavements should be constructed only on a dry base when the weather is not rainy. Atmospheric temperature should be above 50°F. Mixing should take place at the temperature of the aggregate, but not below 50°F or above the recommended temperature of the liquid asphalt being used. The construction procedure depends upon whether the base is a newly constructed base, a scarified existing base, or an existing pavement.

When a newly constructed base is used, perform the following procedure:

1. Inspect and condition the base.
2. Prime the base and allow the prime to cure.
3. Haul in and windrow the aggregate at the side of the primed base. (Allow the aggregate to dry or aerate with a blade when wet.)
4. Spread the aggregate on the cured prime base one half of the roadbed width.
5. Spray the bitumen on the aggregate in increments of about one third of the total amount required.
6. Mix the bitumen with the aggregate; blade back and forth until a uniform mix is obtained.
7. Repeat as directed in (5) and (6) until thoroughly mixed.
8. Spread the mix to the specified thickness.
9. Compact the surface.
10. Apply a seal coat when necessary.

For a scarified base, the aggregate is scarified when it is not available from other sources. The construction procedures are as follows:

1. Loosen the aggregate from the base.
2. Dry and breakup all lumps of material.
3. Blade into parallel windrows of uniform size at one side or in the center.
4. Sweep the base, when needed
5. Prime the base and allow time to cure.
6. Continue as directed in (4) through (10) in the above procedures for a newly constructed base.

When an existing pavement is to be used as a base, the construction procedures are as follows:

1. Sweep the base.
2. Apply a tack coat and allow it to cure.
3. Bring in the aggregate and deposit in windrows at the side of the cured, tacked base.
4. Aerate the aggregate.
5. Spread the aggregate on one half of the tacked base.
6. Spray bitumen on the aggregate in increments of about one third of the total amount required
7. Mix the bitumen with the aggregate by blade.
8. Spread the mix to specified uncompacted thickness.

9. Compact the surface.

10. Apply a seal coat when necessary.

When you are mixing in place (road mix), here are some helpful hints:

1. Do not try to buck nature; stop operations when you are working under adverse weather conditions.

2. Keep the mixture or aggregate in a well-packed windrow for better water shedding and control.

3. Provide drainage cuts through the windrow during heavy rains.

4. When a grader comes to the end of a section with a full blade, lift the blade rapidly to avoid carrying materials into the next section.

5. The distributor spray must be cut sharply at sectional joints; carry-over to the next section will cause undesirable fat joints.

6. Plan the work to avoid inconvenience to traffic.

7. Apply the asphalt at the recommended spraying viscosity to ensure uniform application.

8. Using a shoe on the outer end of the grader blade or moldboard helps obtain a good edge during spreading operations.

9. Aggregate in shaded areas usually requires extra aeration.

ROAD-MIXING METHODS

Two methods of road mixing are travel plant mixing and blade mixing.

Travel Plant Mixing

When a travel plant is used for mixing (fig. 16-7), the loose aggregate is dumped, mixed, and bladed into uniform windrows, and evened when necessary. The windrow should be sufficient to cover the section of the area to be paved with enough loose material to give the desired compacted depth and width. As the bucket loader tows the mixer and elevates the aggregate to the mixer hopper, the mixer meters the aggregate, sprays it with the correct amount of bitumen, mixes these two uniformly, and redeposits the mix into another windrow behind the plant. The rate of travel and the mixing operation should be controlled so that all particles of the aggregate are coated and the mix is uniform. Accuracy in proportioning the mix is extremely important.

The travel plant method usually produces a more uniform mix of higher quality than blade mixing.

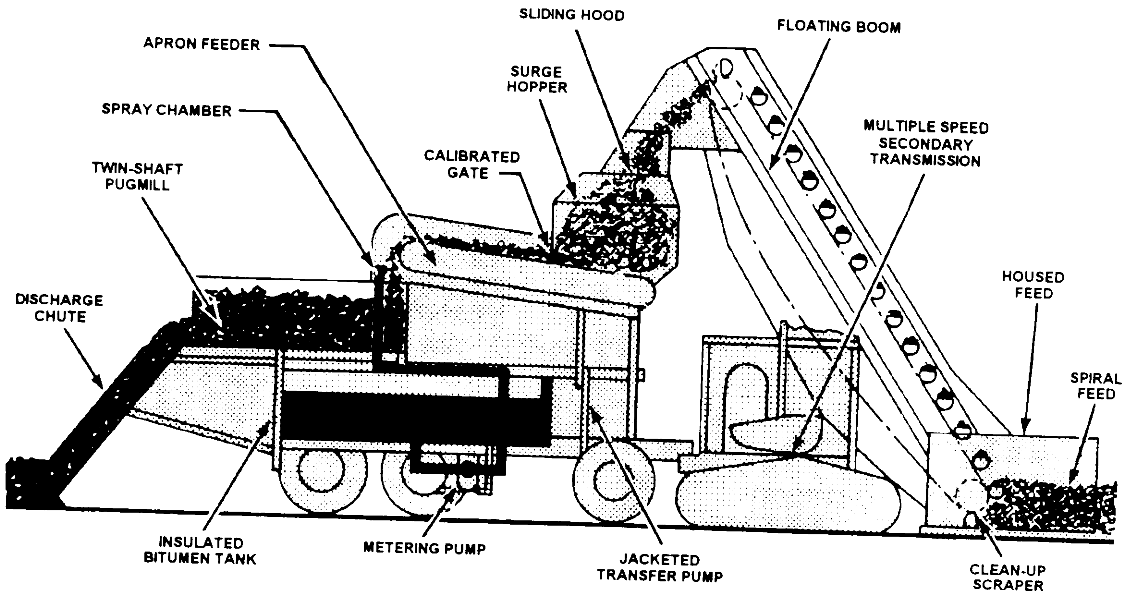

SLIDING HOOD
FLOATING BOOM
APRON FEEDER
SURGE HOPPER
SPRAY CHAMBER
MULTIPLE SPEED SECONDARY TRANSMISSION
CALIBRATED GATE
TWIN-SHAFT PUGMILL
HOUSED FEED
DISCHARGE CHUTE
SPIRAL FEED
INSULATED BITUMEN TANK
METERING PUMP
JACKETED TRANSFER PUMP
CLEAN-UP SCRAPER

Figure 16-7.–Schematic layout of a travel plant.

Heavier types of asphalt cutback and tar maybe used in the travel plant method, which reduces the time required for curing. The asphalt finisher may be used concurrently with the travel plant. The hopper of the finisher is kept directly under the travel plant output chute. This arrangement reduces the maximum output of the plant, although it does provide uniform thickness of the mat being laid.

Windrows must contain no more material than the finisher can place. The major advantage of this setup is that in-place aggregate may be used in an intermediate mix and placed with a finisher without the necessity of loading and transporting aggregate. The finisher must be used with the travel plant for construction of some airfields when surface tolerances are critical.

Blade Mixing

In blade mixing, the aggregate is dried and bladed into windrows (fig. 16-8). The windrows are then flattened and the bitumen of the specific temperature is

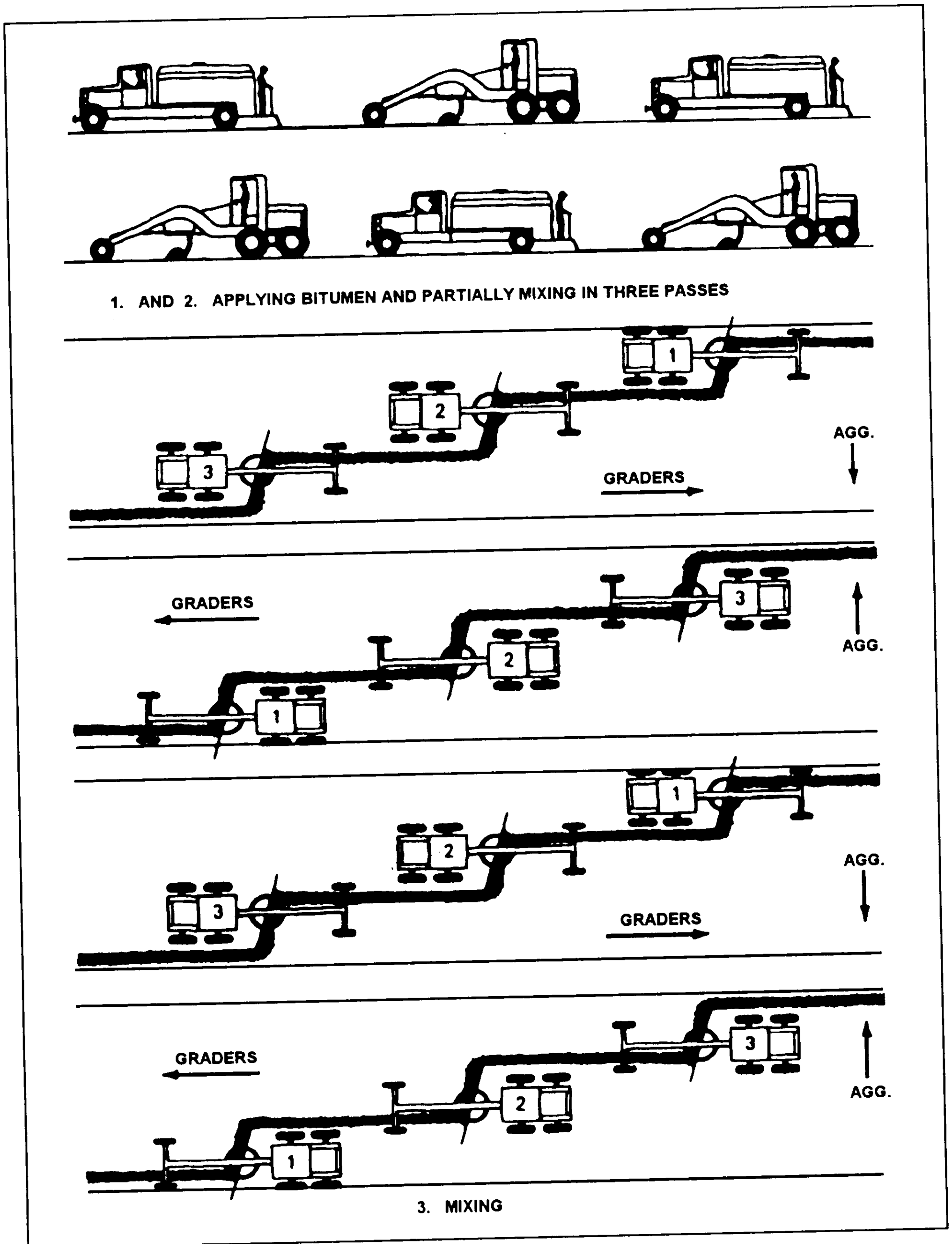

1. AND 2. APPLYING BITUMEN AND PARTIALLY MIXING IN THREE PASSES
1
2
3
AGG.
GRADERS
GRADERS
3
2
1
AGG.
1
2
3
AGG.
GRADERS
GRADERS
3
2
1
AGG.
3. MIXING

Figure 16-8.-Blade-mix construction.

applied with a bituminous distributor in three equal applications. Each application is one-third of the amount required.

Immediately following each application of the bituminous material, the treated aggregate should be mixed with spring-tooth or double-disk harrows, graders, rotary tillers, or a combination of this equipment until all the particles of the aggregate are evenly coated. When a grader is used, the windrow is moved from side-to-side by successive cuts with the blade.

Several graders can operate, one behind the other, to reduce the total time required for complete mixing. In hilly terrain, blading should be from the bottom to the top, as the mix tends to migrate down. After all the aggregate has been mixed, the mix should be bladed into a single windrow at or near the center of the road and turned not less than four complete turns from one side of the road to the other. Excess bitumen, a deficiency of bitumen, or uneven mix should be corrected by the addition of aggregate or bituminous material, followed by remixing. Mixing should continue until it is complete and satisfactory; remember, mix will set up if mixed too long.

Suppose that materials, weather conditions, and equipment are well-suited to mixed-in-place paving, but the road or airfield must carry traffic during construction. In such cases, the windrowing of aggregate and the mixing and spreading of bitumen may be done elsewhere–on any area of smooth ground which can be compacted for the purpose or on any unused road or airfield surface. The road or airfield surface, base, or subgrade to be paved is then primed or tack-coated as required to complete construction and to keep portions of the road or airfield open to traffic. As soon as the prime or tack coat cures, the mix is picked up, trucked to the jobsite, dumped, and then bladed into windrows for spreading.

The bituminous mix should not be spread when the surface is damp or when the mix itself contains an excess of moisture. The mixed material should be spread to the required width in thin, equal layers by a grader or finisher. (When a finisher is used, additional support equipment is required, and the material must be split into two windrows for an 8- to 12-foot-wide pavement.) When spreading the mix from a windrow, you should take care to prevent cutting into the underlying subgrade or base course. To prevent such cutting, you should leave a layer of mix, approximately one-half inch thick, at the bottom of the windrow.

The material being spread should be rolled once and then leveled with a grader to remove irregularities. The remaining material should be spread and rolled in thin layers until the entire mix is evenly spread to the depth and width specified. During the spreading and compacting, the surface should be dragged or bladed, as necessary, to fill any ruts and to remove corrugations, waves, or other irregularities. Both pneumatic-tired and steel-wheeled rollers may be used for rolling all surface treatment jobs; however, the pneumatic-tired roller is the preferred type.

After all layers have been satisfactorily spread, the surface should be rolled with two-axle tandem rollers. Rolling should begin at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one half of the width of the wheel of the roller. Alternate trips of the roller should be of different lengths. The speed of the roller at all times should be controlled to avoid displacement of the mix. Light blading (or floating) of the surface with the grader during rolling may be required. Rolling should be continued until all roller marks are eliminated and maximum density is obtained. To prevent adhesion of the mix to the roller, you should keep the roller wheel moist with water; use only enough water to avoid picking up the material. At places not accessible to the roller, the mix should be thoroughly compacted with hand tampers. When the surface course becomes rough, corrugated, uneven in texture, water soaked, or traffic marked, unsatisfactory portions should be tom up and reworked, relaid, or replaced. When forms are not used and while the surface is being compacted and finished, the outside edges should be trimmed neatly in line.

When the road-mix pavement surface course is constructed from an open-graded aggregate, a surfs treatment may be required to waterproof the surface. A surface treatment is unnecessary on a dense-graded, well-compacted, road-mix pavement.

When possible, traffic should be kept off freshly sprayed asphalt or mixed materials. When it is necessary to route traffic over the new work speed must be restricted to 25 mph or less until rolling is completed and the asphalt mixture is firm enough to withstand high-speed traffic.

DEFECTS IN FLEXIBLE PAVEMENTS

Defects inflexible pavements can be placed into one of five classes. These classes are cracking, distortion, disintegration, slippery surfaces, and surface treatment problems.

Cracking

Cracking takes many forms. To make the proper repairs, first you should determine the type of crack and the cause. The most common types of cracks are alligator, edge, edge joint, lane joint, reflection, shrinkage, and slippage.

ALLIGATOR CRACKS.— Alligator cracks are interconnected cracks, forming a series of small blocks resembling an alligator's skin or chicken wire (fig. 16-9). In most cases, alligator cracking is caused by excessive movement of the surface over unstable subgrades or base courses. The unstable support is the result of saturated granular bases or subgrade. Normally, the affected area is not large. When it does occur on a large scale, the cracking is most likely due to repeated loads above the designed strength of the pavement.

EDGE CRACKS.— Edge cracks are longitudinal cracks approximately 1 foot from the edge of the pavement (fig. 16-10). Edge cracks can have transverse cracks, branching in towards the shoulder. Normally, edge crack are caused by a lack of side or shoulder support. They may also be caused by settlement or yielding of the base material underlying the cracked area. This, in turn, may be the result of poor drainage, frost heave, or shrinkage from the drying out of the surrounding earth.

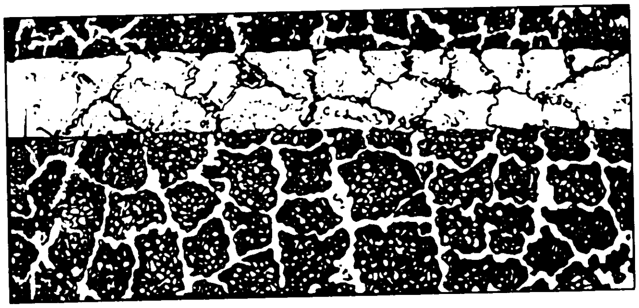


Figure 16-9.—Alligator cracks.

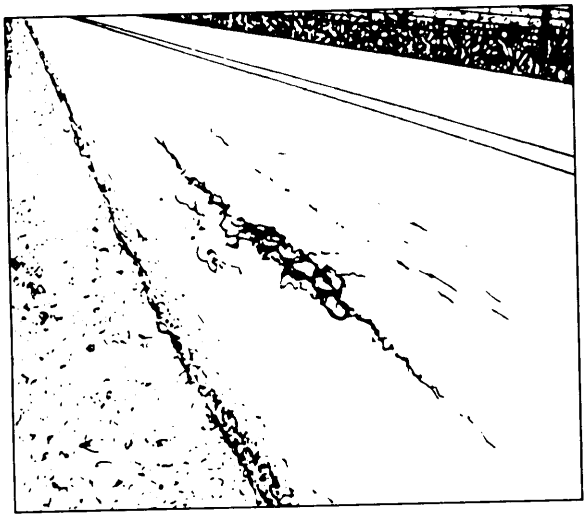


Figure 16-10.-Edge cracks.

EDGE JOINT CRACKS.— Edge joint cracks occur between the pavement and the shoulder (fig. 16-11). They are normally caused by alternate wetting and drying beneath the shoulder surface. This can result from poor drainage from a shoulder that is too high, or it can result from depressions along the pavement edge. The uneven pavement traps water on top, allowing it to seep into the base. Another cause could be heavy trucks, straddling the joint.

LANE JOINT CRACKS.— Lane joint cracks are longitudinal separations along the seam between two paving lanes (fig. 16-12). This type of crack is usually caused by a weak seam or poor bond between adjoining spreads in the pavement.

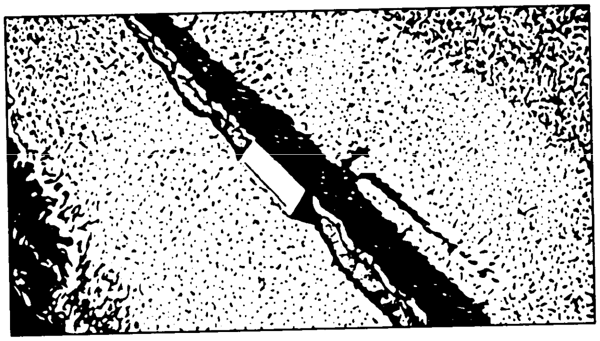


Figure 16-11.-Edge joint cracks.

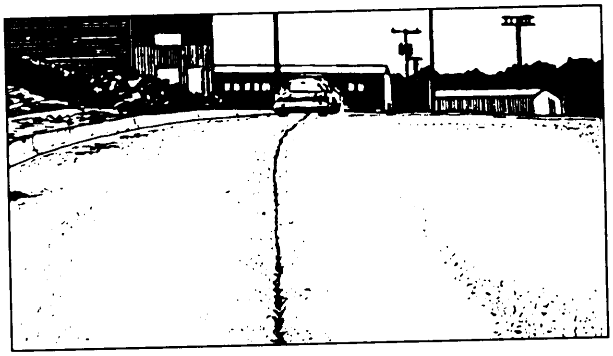


Figure 16-12.-Lane joint cracks.

REFLECTION CRACKS.— Reflection cracks normally occur in asphalt overlays. These cracks reflect the crack pattern in the pavement structure underneath (fig. 16- 13). They are most frequently found in asphalt overlays over portland concrete and cement-treated bases. Reflection cracks are normally caused by vertical or horizontal movements in the pavement beneath the overlay, resulting from traffic loads, temperature, and earth movements.

SHRINKAGE CRACKS.— Shrinkage cracks are interconnected cracks, forming a series of large blocks usually with sharp corners or angles (fig. 16-14). Often it is difficult to determine whether shrinkage cracks are caused by volume change in the asphalt mix or in the base or subgrade. Frequently, they are caused by volume change of fine aggregate asphalt mixes that have a high content of high-viscosity asphalt. Lack of traffic hastens shrinkage in these pavements.

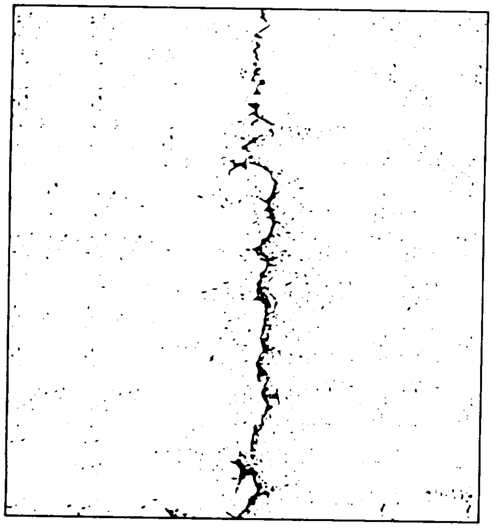


Figure 16-13.-Reflection cracks.

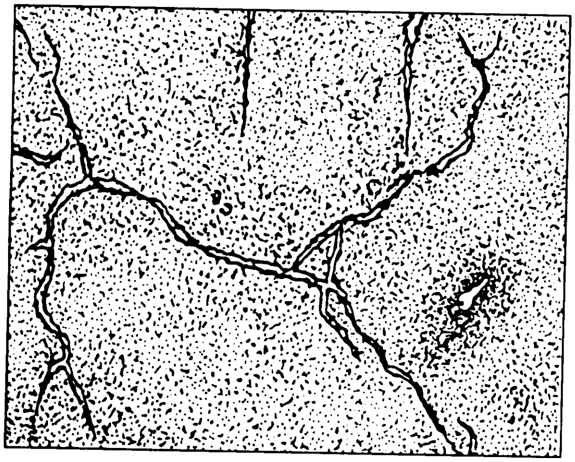


Figure 16-14.—Shinkage cracks.

SLIPPAGE CRACKS.— Slippage cracks are crescent-shaped cracks, resulting from horizontal forces induced by traffic (fig. 16-15). They are caused by a lack of bond between the surface layer and the course beneath. Lack of bond maybe due to dust, dirt, oil, or the absence of a tack coat.

Distortion

Pavement distortion is any change in a flexible pavement surface. It is the result of a subgrade surface. weakness where compaction or movement of the subgrade soil has taken place or where base compaction has occurred. It may or may not be accompanied by cracking, but in either instance, it creates a traffic hazard, permits water to accumulate, and eventually makes matters worse. Distortion takes a number of different forms but is normally classed as channeling, corrugations and shoving, depressions, and upheaval.

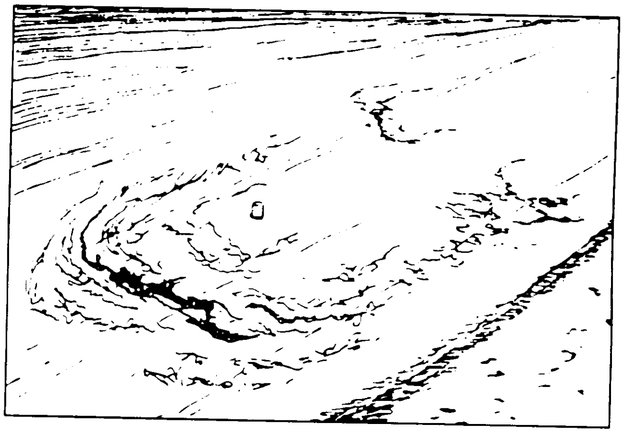


Figure 16-15.–Slippage cracks.

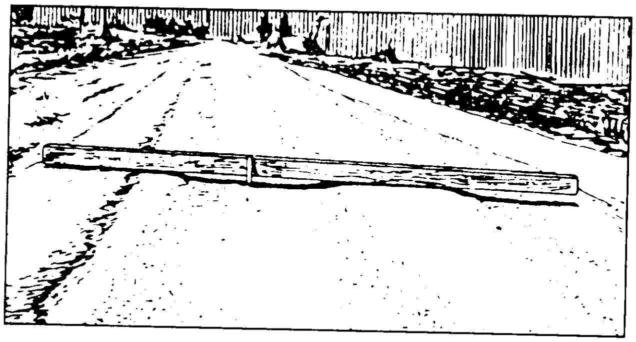


Figure 16-16.–Channeling.

CHANNELING.— Channeling, also referred to as "grooving" or "rutting," is channelized depressions that develop in the wheel tracks of flexible pavements (fig. 16-16). Channeling may result by consolidation or lateral movement under traffic in one or more of the underlying courses or by displacement in the bituminous surface itself. It may develop under traffic in new flexible pavements that had too little compaction during construction or from plastic movement in a mix that does not have enough stability to support traffic.

CORRUGATIONS AND SHOVING.— Corrugation, or washboarding, are a form of plastic movement typified by ripples across the flexible pavement surface (fig. 16-17). Shoving is the plastic movement of the pavement, resulting in localized bulging of the pavement (fig. 16-18). Both corrugations and shoving normally occur at points where traffic starts and stops or on hills where vehicles brake on the downgrade.

Corrugations and shoving usually occur in flexible pavement mixtures that lack stability. This may be the result of too much binder, too much fine aggregate, or round- or smooth-textured coarse aggregate. In the case of emulsified and cutback asphalt mixes, it maybe due to a lack of aeration.

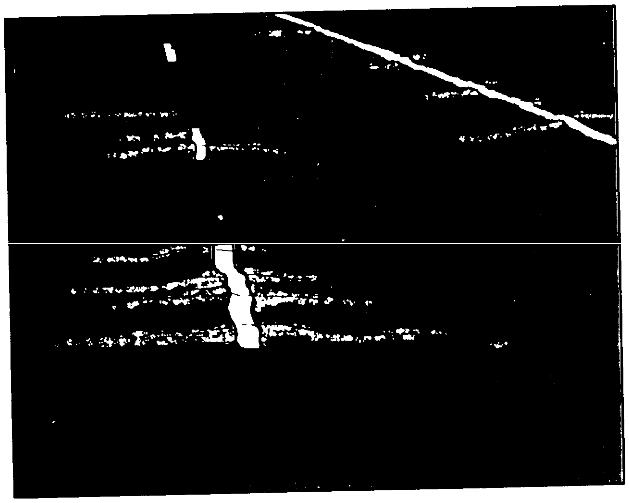


Figure 16-17.-Corrugations.

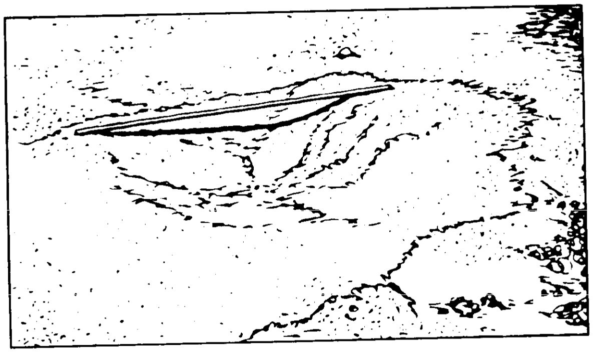


Figure 16-18.-Shoving.

DEPRESSIONS. — Depressions are localized areas of limited size that may or may not be accompanied by cracking (fig. 16-19). Water collects in depressions that then become not a source of pavement deterioration but a hazard to motorists. Depressions are caused by traffic heavier than that for which the pavement was designed, by poor construction methods, or by consolidation deep within the subgrade.

UPHEAVAL.— Upheaval is the localized upward displacement of the pavement due to swelling of the subgrade or some portion of the pavement structure (fig. 16-20). It is commonly caused by ice expansion in the granular courses beneath the pavement or in the

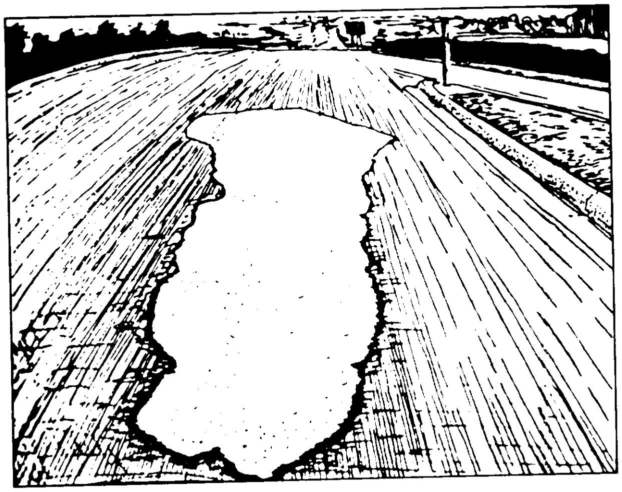


Figure 16-19.—Depression.

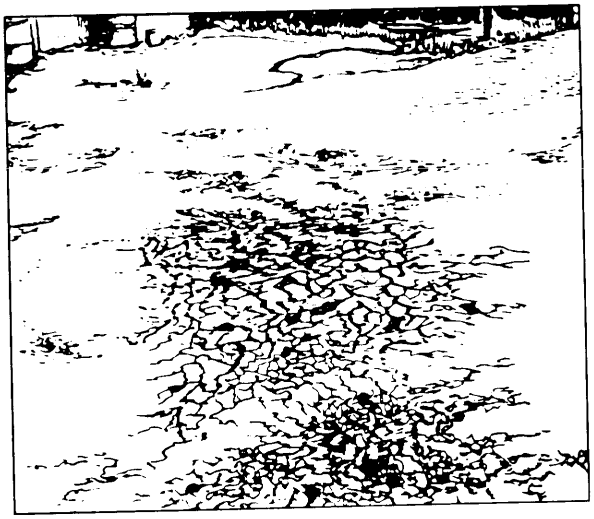


Figure 16-20.—Upheaval.

subgrade. Upheaval may also be caused by the swelling effect of moisture on expansive soils.

Disintegration

Disintegration is the breaking up of a pavement into small, loose fragments. This includes the dislodging of aggregate particles. If not stopped in its early stages, disintegration can progress until the pavement requires complete rebuilding. Potholes and raveling are two of the more common types of early stage disintegration.

POTHOLES.— Potholes are bowl-shaped holes of various sizes in the pavement, resulting from localized disintegration under traffic (fig. 16-21). They are usually caused by weakness in the pavement, resulting from too little binder, too thin a surface, too many fines, or poor drainage.

RAVELING.— Raveling is the progressive loss of surface material by weathering or traffic abrasion (fig. 16-22). Usually the fine aggregate wears away first, leaving little pockmarks in the pavement surface. As erosion continues, larger particles eventually break free, and the pavement soon has the rough and jagged appearance, typical of surface erosion. Raveling is caused by poor construction methods, inferior aggregates, or poor mix design.

Slippery Surfaces

One of the most common causes of a slippery flexible pavement is a thin film of water over a smooth surface. his can cause a vehicle to hydroplane. Other causes of slippery surface in flexible pavements are bleeding and polished aggregates.

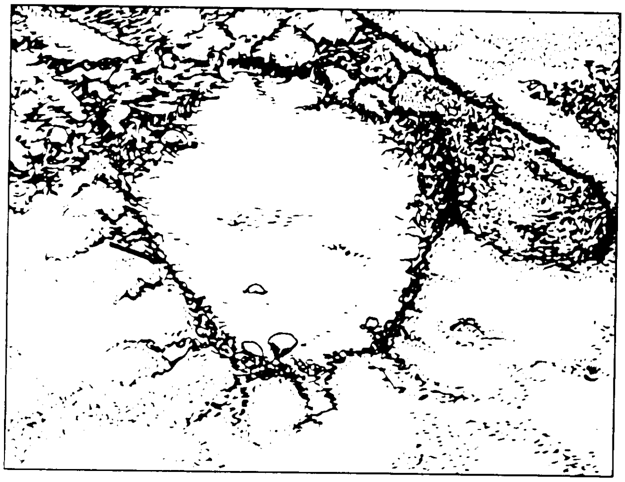


Figure 16-21.-Pothole.

Figure 16-22.—Raveling.

BLEEDING AGGREGATES.— Bleeding is the upward movement of bituminous material in a flexible pavement, resulting in the formation of a film of bituminous material on the surface (fig. 16-23). The most common cause of bleeding is too much asphalt in one or more of the pavement layers. This is usually the result of a rich plant mix or a prime or tack coat that is too heavy. Bleeding normally occurs in hot weather.

POLISHED AGGREGATES.— Polished aggregates are those that have been worn smooth under traffic (fig. 16-24). Polished aggregates are caused by using the wrong type of aggregate in the pavement mix.

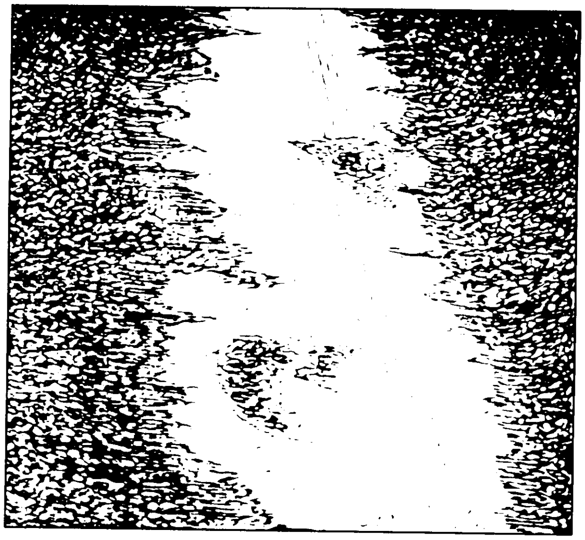


Figure 16-23.-Bleeding asphalt.

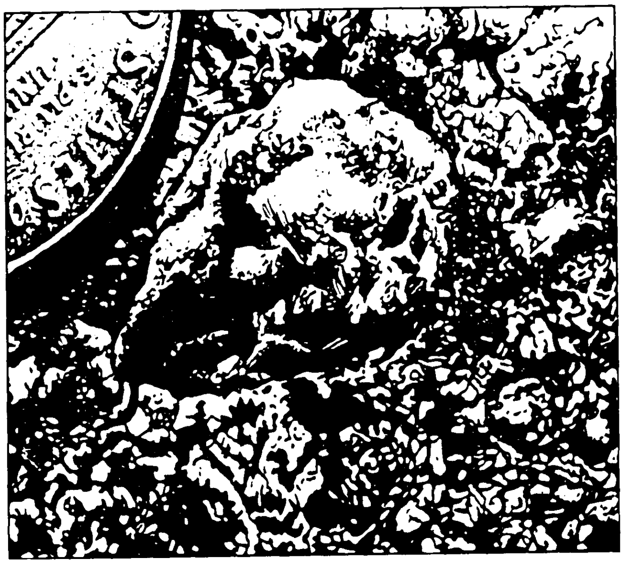


Figure 16-24.—Polished aggregate in pavement surface.

REPAIRING DEFECTIVE FLEXIBLE PAVEMENTS

Care and good judgment are necessary in applying suitable methods and in selection of proper materials for maintenance and repairs of bituminous surfaces. Both methods and materials vary considerably with local conditions, but the principles of bituminous work remain the same. The first step in making repairs is to determine the cause of the failure. Repairs must start at the source of the failure.

Removing Defective Flexible Pavement

The first step in removing a defective area is to mark out the area you want to remove. If you are going to use a pavement saw to cut the pavement, make your marks heavy and easy to use. The marks should be made with a waterproof material, such as paint or crayon, to prevent it from being washed off by the saw blade. The shape of the patch is important. If you expect the patch to be strong enough to support traffic, you must make the marked area square or rectangular in shape with two faces at right angles to the flow of traffic. By doing this, you will ensure the patch does not shove or corrugate when traffic flows over the top of it.

PAVEMENT CUTTING.— After you mark the area you want to remove, you are now ready to make your cuts along the marks. You can do this by using a pavement saw to make a fast, neat cut or by using a pneumatic hammer with a 5-inch asphalt cutting bit. When the pneumatic hammer is used, it leaves the edges of the patch jagged. When making the cut with either tool, make sure the patch has square edges and is rectangular in shape. The cut should also extend at least a foot into the good pavement.

PAVEMENT REMOVAL.— After the outline cuts have been made, you can begin to breakup the defective material with a pneumatic hammer. Break the pavement into pieces that can be removed easily by hand. If the pieces are too large, a front-end loader maybe required to remove them. After the pavement has been broken up, the pieces can then be removed and hauled away (fig. 16-25).

After the pavement has been removed, check the condition of the base course material. When the base course is saturated with water, this material should be removed until you reach firm, dry soil. The sides should be vertical and the bottom as level as possible.

Base Course Replacement

After the hole is excavated, clean out all loose debris with hand brooms. When the hole is wet, it must be allowed to dry. When the hole is deeper than the pavement, it should be filled with dense-graded aggregate. Fill and compact it in 2-inch lifts up to the lower edge of the pavement. On large patches, compaction can be done with a roller. Small patches must be hand-tamped. On large patches, the edges must be hand-tamped.

NOTE: Specification may require that a compaction test be performed on the base course before a prime coat application.

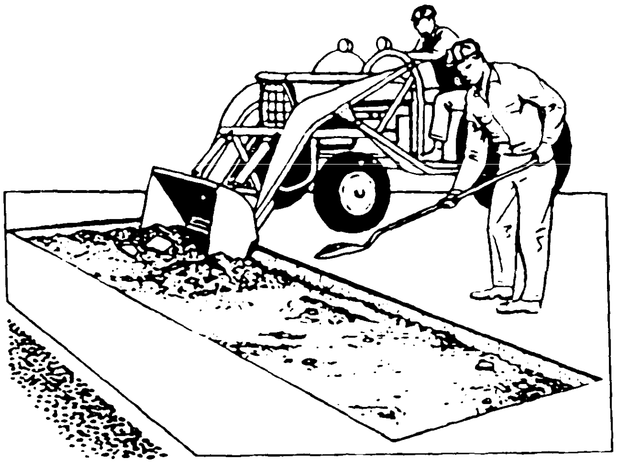


Figure 16-25.-Removing defective flexible pavement.

After the base course has passed the compaction test, prime the hole with a light application of asphalt, which can either be sprayed or brushed on. The prime material must be thin enough so that it can be applied lightly.

NOTE: An excess of asphalt prime coat will flush into the patch mix and causes bleeding.

The final step in the preparation of the hole is to apply a tack coat to the vertical faces, as shown in figure 16-26.

Bituminous Materials Replacement

The first step in the replacement of the paving materials is to obtain a sufficient quantity of material to complete the project. Use a hot mix if possible because it is stronger and lasts much longer. To allow for compaction when using a hot mix, you should overfill the area approximately 40 percent of the pavement thickness. When a cold mix is used, it should be spread and rolled in layers with each layer not to exceed 1 1/2 times the maximum aggregate size in the mix. When cold mix is spread, keep the material as level as possible to prevent segregation. Both hot and cold mixes can be spread by grader, by paver, or by hand, depending on the size of the repair.

Compaction of bituminous materials is done with steel-wheel rollers and pneumatic-tired rollers on larger areas, or with vibrator tampers, vibratory patch rollers, and hand tampers on smaller areas. Compaction is an important part of the patching operation. The rolling operation on hot mix should begin immediately after the material is placed. Cold mix should be rolled after proper aeration of the material. The edges of the patch should be rolled first. This seals the edges and prevents the material from dishing out and water from infiltrating. When cold mix is used, the patch may have a porous surface and require waterproofing. This can be done by applying a sand seal or by applying a thin layer of portland cement and tamping it in.

Obtaining a smooth riding surface requires care. Too many patches are built as mounds that result as bumps in the road A straightedge should be used as a guide to finish the patch. The patch should not be lower than the rest of the pavement. Instead, it should be level with or one-eighth inch higher than the surrounding area. Figure 16-27 shows the steps in patching a pothole.

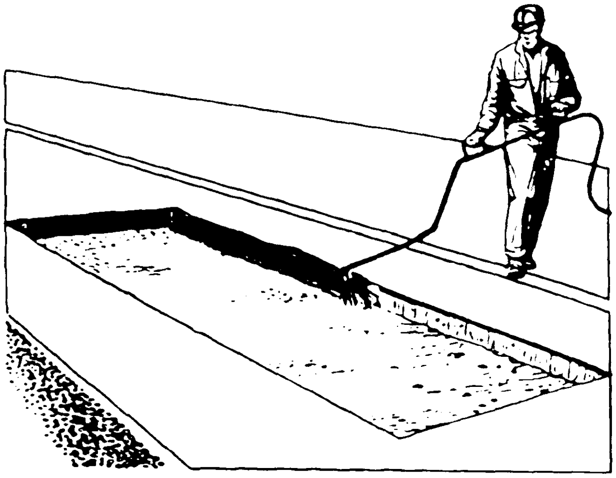


Figure 16-26.-Tack coat application to the vertical faces.

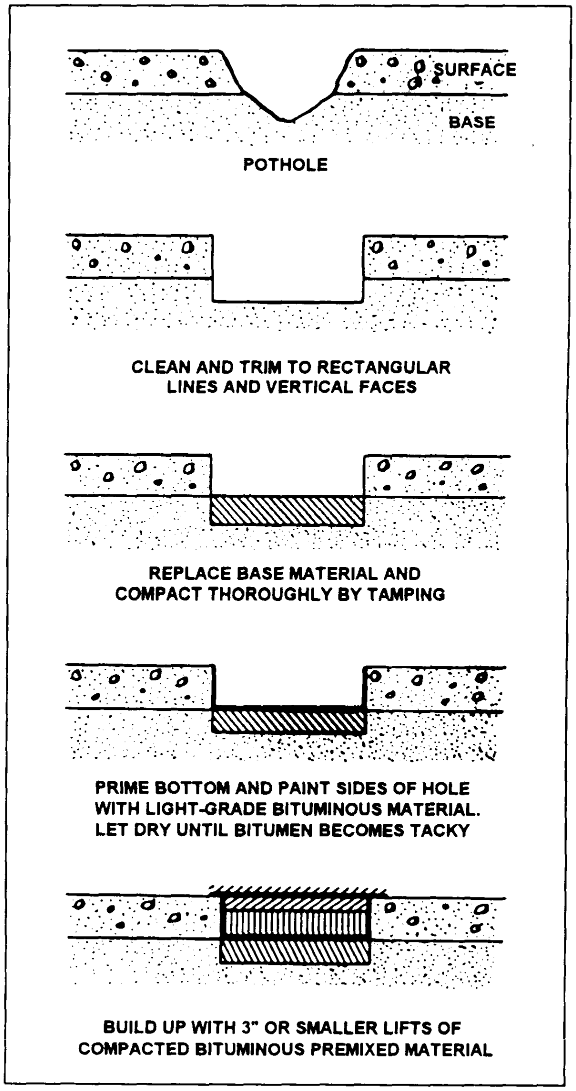

SURFACE
BASE
POTHOLE
CLEAN AND TRIM TO RECTANGULAR LINES AND VERTICAL FACES
REPLACE BASE MATERIAL AND COMPACT THOROUGHLY BY TAMPING
PRIME BOTTOM AND PAINT SIDES OF HOLE WITH LIGHT-GRADE BITUMINOUS MATERIAL. LET DRY UNTIL BITUMEN BECOMES TACKY
BUILD UP WITH 3" OR SMALLER LIFTS OF COMPACTED BITUMINOUS PREMIXED MATERIAL

Figure 16-27.-Steps in patching a pothole.

SURFACE TREATMENTS

A surface treatment is an application of asphalt materials to any type of road surface with or without a cover of mineral aggregate. This application produces an increase in thickness usually less than 1 inch. Surface treatments have a variety of uses. They waterproof, provide a nonskid wearing surface, and rejuvenate an old surface.

Purposes

The simplest types of bituminous surfaces that may be placed over prepared surfaces are called surface treatments. Surface treatments are applications of bituminous material to any type of base or pavement surfaces which, together with an aggregate cover, produce a pavement with a thickness of 1 inch or less. In some cases, multiple treatments that produce thicker pavements are used.

Surface treatments are applied for one or more of the following purposes:

1. Waterproof the surface.
2. Provide a wearing surface.
3. Make the surface nonskid.
4. Prevent hydroplaning.
5. Rejuvenate an old road or runway.
6. Make permanent improvements.

Types

Surface treatments may be applied to the base course of a new road or to the surface of an old road as a method of repair. Surface treatments are grouped into three categories: sprayed asphalt, sprayed asphalt with cover aggregates, and asphalt-aggregate mixtures.

Sprayed Asphalt Surface Treatment

Sprayed asphalt treatments contain no aggregates. They are simply applications of different types of asphaltic materials to a prepared surface. The categories include fog seals, dust laying, and road oiling. Prime and tack coats are also considered as a sprayed asphalt treatment.

FOG SEAL.— A fog seal is a light application of diluted slow-setting asphalt emulsion, used to renew old asphalt surfaces and seal small cracks and surface voids. Fog seals are especially useful for pavements carrying a low volume of traffic. A fog seal may also be used for the following:

1. To seal surface voids in new asphalt plant mixes
2. To prevent dust on sprayed asphalt with cover aggregate surface treatments
3. To increase aggregate retention
4. To provide a uniform dark color

The asphalt emulsion is diluted with an equal amount of water, and the diluted material is sprayed at the ROA of 0.1 to 0.2 gallon per square yard, depending on the texture and dryness of the old pavement. In normal conditions, the separation and evaporation of the water is rapid, permitting traffic within 1 or 2 hours.

DUST LAYING.— Dust laying consists of spraying an untreated surface with a low-viscosity liquid asphalt, such as SC-70, MC-30, MC-70, or a diluted slow-setting asphalt emulsion. The asphalt and dilutant penetrate and coat the fine particles and temporarily relieve the nuisance of dust.

The material is sprayed at a ROA of 0.1 to 0.5 gallon per square yard. When emulsion is used, it should be diluted with 5 or more parts of water by volume. Diluted emulsion dust-laying treatments usually require several applications. The dust stirred by traffic between applications eventually conglomerates and no longer rises. This is an effective treatment in a very dusty environment where one application of asphalt is insufficient.

ROAD OILING.— Road oiling differs from dust laying in that it is usually accomplished as part of a planned buildup of low-cost road surfaces over several years. Each application may be mechanically mixed with the material being treated, or it maybe allowed to penetrate. The light oils in the road oil penetrate into the subgrade and tend to repel moisture absorption. The objective in all road oiling work is to form a dustless wearing surface, combined with a strong water-repelling subgrade.

Because soils vary widely, procedures for oiling are a matter for local trial and error, rather than scientific analysis. The amount of road oil, required in the first year of work will vary from 0.75 to 1.0 gallon per square yard. The first application is applied at the ROA of about one half of the total; succeeding applications are made in equal amounts.

Road oiling treatments are placed several weeks apart, depending upon the character of the asphalt soil mat. If some breakup occurs after the first winter, light scarifying and retreatment the second year will produce a thicker and stronger surface.

WARNING

Before planning any road oiling work your supervisor should check with local authorities concerning environmental protection restrictions.

Aggregate Surface Treatment

The sprayed asphalt with aggregate cover surface treatments are applications of liquid asphalt, followed by an application of aggregate. This can be done in one or more layers of construction. Two types of sprayed asphalt with covered aggregate surface treatments are in use today: single- and multiple-surface treatments.

SINGLE-SURFACE TREATMENT.— Single-surface treatments are thin, bituminous-aggregate toppings, applied to existing bases or surfaces, such as concrete or asphalt. Construction involves applying a bituminous prime or tack coat to the base or surface. This coating is followed by an application of bitumen and small-sized aggregate. Single-surface treatments are sometimes called seal coats, because they seal the surface of the road or runway.

Sequence of Operations.— Figure 16-28 shows the sequence of operations for the application of a single-surface treatment. The first steps, such as sweeping, priming or tacking, and curing, are the same as those used for applying a prime coat. The binder (bituminous material) is applied over the prime coat with an asphalt distributor. The aggregate is then spread over the binder by use of aggregate spreaders. The aggregate cover is spread uniformly immediately behind the distributor. As soon as the aggregate is spread, it is pushed into the soft asphalt by rolling it with a pneumatic-tired roller.

Binder Application.— When you are applying the binder, it should be hot enough to spray properly and

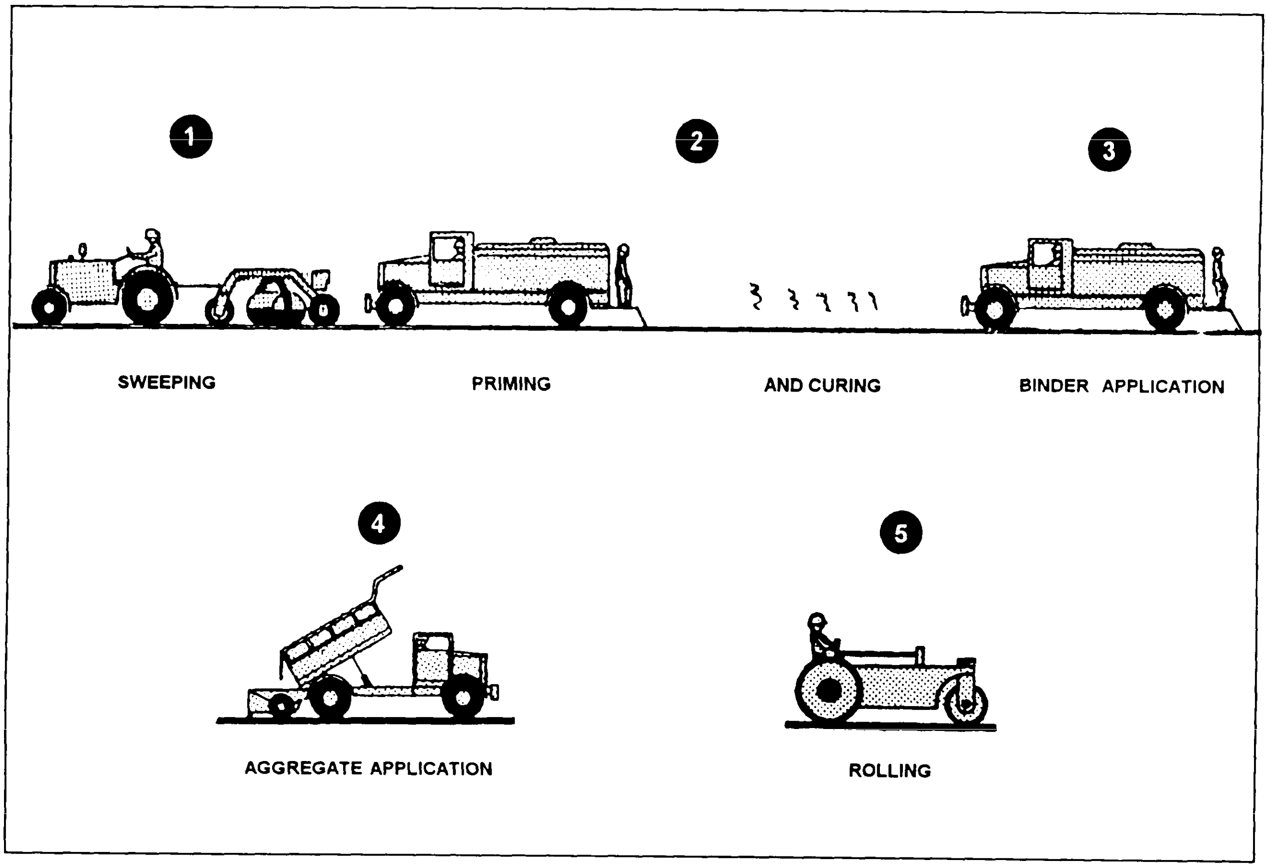


Figure 16-28.-Sequence of operations for the application of a single-surface treatment.

cover the surface uniformly. After the binder cools and cures, it should bind the aggregate tightly to prevent dislodgement by traffic. Individual aggregate stones should be pressed into the binder but must not be covered by the binder. Approximately one half of the individual aggregate stones should be exposed to traffic. The ROA for the binder material should be between 0.25 and 0.30 gallon of aspalt per square yard.

For a single-surface treatment, the bitumen must be heated and applied to the surface while hot. The aggregate must be spread and rolled before the bitumen cools. Under no circumstances is traffic permitted to travel upon uncovered fresh bitumen. The distributor should NOT apply bitumen until the aggregate is on hand and ready for application. When the distributor moves forward to spray the asphalt, the aggregate spreader should start right behind it. The bitumen should be covered within 1 minute if possible; otherwise, the increase in asphalt viscosity may prevent good binding of aggregate.

Aggregate Application.— The size and amount of aggregate, used for surface treatments, are important. You must use a size that matches the bitumen application rate. For a single-surface treatment, one-half inch to sieve number 4 is needed. The amount of aggregate should be 25-30 pounds per square yard.

When aggregate is distributed properly, very little hand work is required. At longitudinal joints, the aggregate cover is stopped 8 inches from the edge of the bitumen to ensure ample overlap of the bitumen coat. All bare spots should be covered by hand spreading, and any irregularities of the distribution should be corrected with hand brooms. Excess aggregate in limited areas should be removed immediately with square-pointed shovels. When the aggregate spreader is properly set and operated, handwork is reduced to a minimum.

Rolling.— The aggregate is usually rolled by pneumatic-tired rollers. Steel-wheeled rollers are not recommended by themselves. If used, they should make only one pass (one trip in each direction). The rolling operation should then be completed with the pneumatic-tired rolls. Steel-wheeled rollers produce maximum compaction but must be used with care to prevent excessive crushing of the aggregate particles. Also, these rollers will bridge over smaller size particles and small depressions in the surface and will fail to press the aggregate in these places in the asphalt.

Faulty rolling can be eliminated or minimized if you adhere to the following procedures:

1. Rolling should be parallel to the center line of the roadway to reduce the number of times the roller must change direction.

2. Succeeding passes should overlap one half of the wheel width of the roller. This action ensures that the aggregate becomes well embedded in the bitumen.

3. Rolling should be completed before the bitumen hardens. This will ensure that the aggregate becomes well embedded in the bitumen.

4. Succeeding passes should be made from the low side to the high side of the surface. This operation maintains the surface crown and prevents feathering at the edges.

5. Rolling should be done at a slow speed.

6. Rollers should be only wet enough to prevent bitumen from sticking to the wheels.

7. The power wheel of the roller should pass over the unrolled surface before the steering wheel(s) of the rollers.

After rolling and curing, the surface is ready for traffic. When the surface is used as an airfield, excess aggregate must be swept from the surface to avoid damage to aircraft. This practice is also recommended for roads.

MULTIPLE-SURFACE TREATMENT.— A multiple-surface treatment is essentially the same as the single-surface treatment. However, the multiple-surface treatment consists of two or more successive layers of binder and aggregate.

This type of treatment is done in stages. Each stage is accomplished in the same manner as a single-surface treatment. The only difference is that each additional layer of aggregate should be about one half of the size of the previous layer. This allows the smaller aggregate to interlock with the larger aggregate when rolled.

PAVING EQUIPMENT

Equipment, used in asphalt pavement construction, are aggregate spreaders, asphalt distributors and their associated hand sprayers and spray bars, asphalt kettles, asphalt haul trucks, and asphalt pavers.

AGGREGATE SPREADERS

When a spreader is operated properly, it will conserve aggregate and produce a uniform spread. Spreaders range from a type attached to a truck tailgate to a highly efficient self-propelled machine.

Several types of tailgate spreaders are in use today. The simplest is the vane spreader (fig. 16-29).

There are tailgate spreaders that consist of a hopper with a feed roller, activated by small wheels driven by contact with the truck wheels (fig. 16-30).

Mechanical spreaders are hoppers on wheels that are hooked onto and are propelled by backing aggregate trucks. Hoppers have various widths and capacities. They usually contain augers to distribute the aggregate the full width of the box. They have controls to regulate feed gates, feed roll, augers, and the truck hitch. All tailgate and mechanical spreaders that are pushed by a truck have the disadvantage that the truck must be operated in reverse with consequent loss of steering control and reduction in speed.

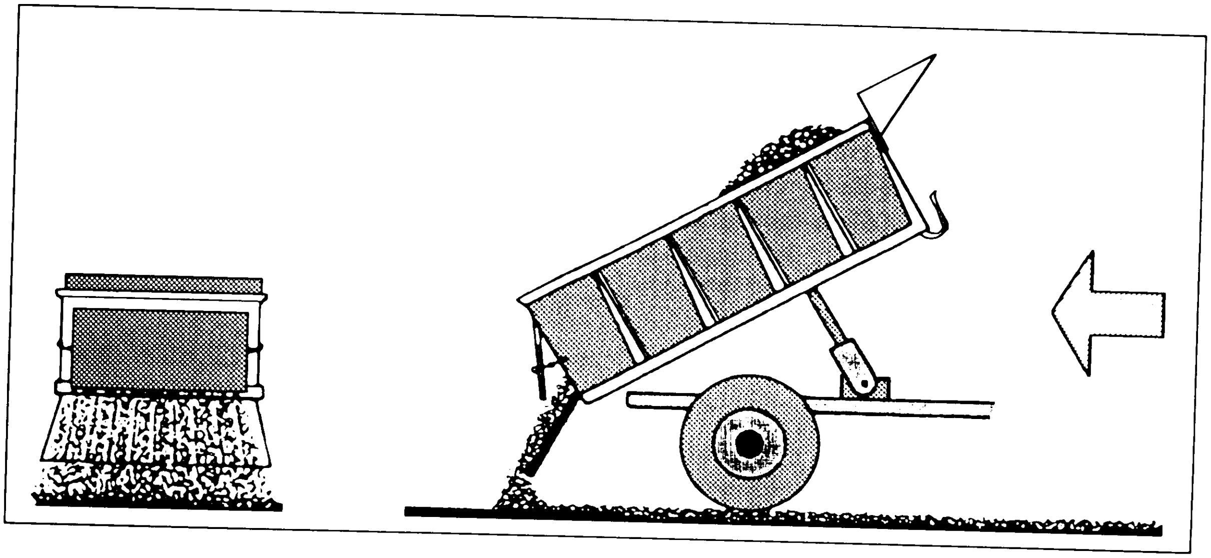


Figure 16-29.—Vane spreader.

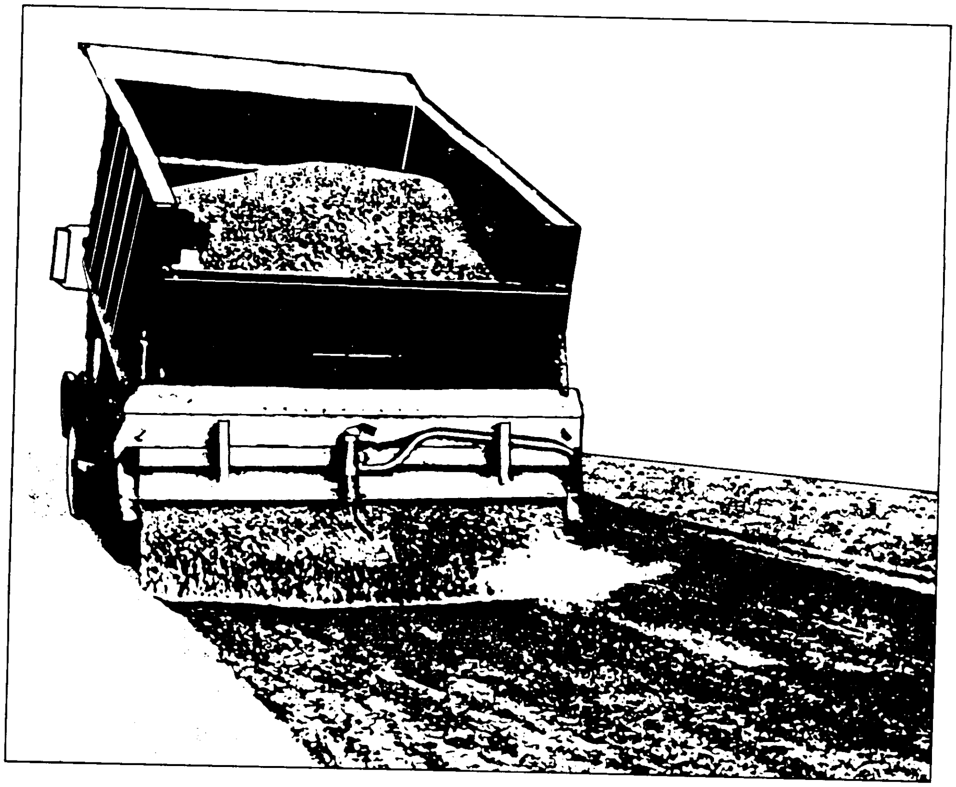


Figure 16-30.-Hopper type of tailgate spreader.

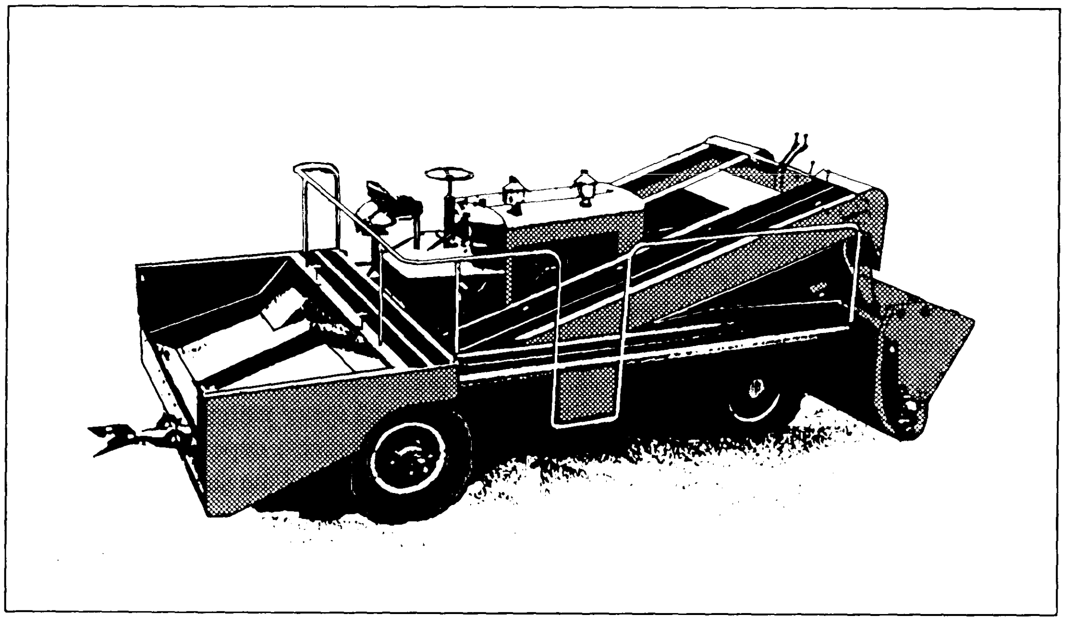
A self-propelled spreader is shown in figure 16-31. This machine moves forward and makes possible a uniform and continuous application of cover aggregate, because it is capable of keeping up with the asphalt distribute. The spreader is self-powered and has a receiving hopper in the rear. Aggregate trucks are hitched to the spreader, dump their loads into the hopper, and are pulled by the spreader. Belt conveyors carry the aggregate to the front of the machine where it is dropped into the spreading hopper (fig. 16-32). Aggregate flows over a spread roll onto a screen that permits initial placement of larger particles on the asphalt, followed by fine aggregate on top.

Calibration and adjustments for all types of aggregate spreaders should be made according to the manufacturer's instruction and operating manual. Here are some additional checks that should be made to ensure good results:

1. A tachometer, used as an aid in maintaining uniform spreader-box speed, is most helpful.

2. Distribution rates are closely controlled by measuring off the length that each truckload of aggregate should cover.

3. A quick check on the rate of application of aggregate can be made by laying a 1-square-meter (yard) section of cloth or building paper on the pavement (or by supporting a shallow l-square-yard box above the asphalt with nails or screws) and by passing over it with the spreader. The cloth, paper, or box is then carefully



Figre 16-31.-Self-propelled aggregate spreader.

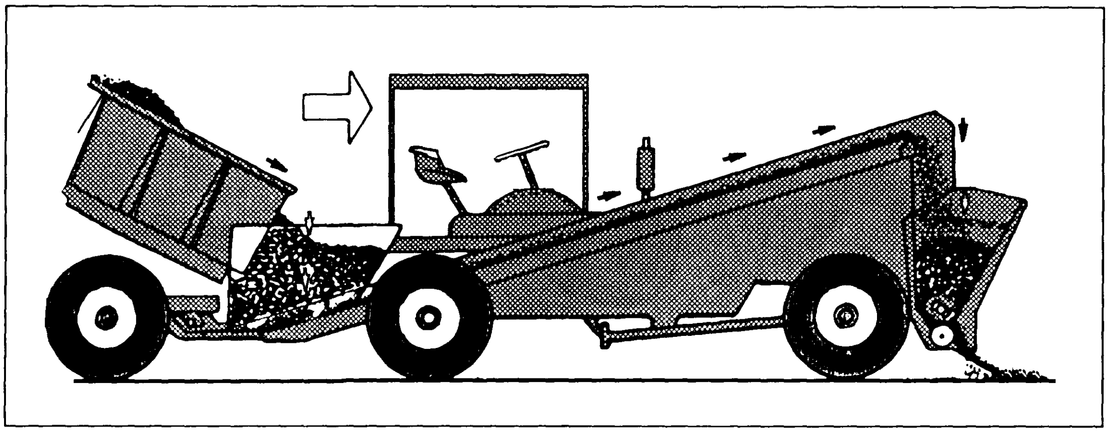


Figure 16-32.—Flow of aggregate through a self-propelled aggregate spreader.

lifted and the aggregate on it is weighed. This will give the weight per square yard of aggregate being spread.

ASPHALT DISTRIBUTOR

The asphalt distributor (fig. 16-33) is a unit consisting of an insulated storage and heating tank, an open flame heating system, an asphalt pump, a low-pressure air blower, and a circulating and spraying system. Power to operate the components is PTO driven.

NOTE: The operation of this truck requires the absolute need for experienced personnel only. Mishaps, resulting in loss of man-days and equipment, are a direct result of this factor being overlooked.

Heating System

The air blower provides low-pressure air to atomize fuel for the burners. The burners heat the tubes, located in the tank. An asphalt covering must be maintained over the fire tubes to prevent them from overheating and causing a fire or explosion. Because the distributor is mobile, care must be taken to ensure that heating is performed in a level area that is well-ventilated and that the distributor truck is not moving at all and is at a COMPLETE HALT. Whenever you are heating cutbacks, the asphalt must be circulating at all times. This is a must to prevent any chance of volatile liquids overheating around the flues, which can be very dangerous.

Spray System

The spray system consists of necessary piping, a series of hand-operated valves to control the flow of bitumen, and an adjustable length spray bar, capable of providing coverage from 4 to 14 feet wide. The spray bar may be the full-circulating or the noncirculating type, depending on the model of the distributor. The spray bar may be equipped with either 1/8-inch nozzles or 3/8-inch nozzles; the 1/8-inch nozzles are used for most applications. The application rate is controlled by the length of the spray bar, the pump output, and the forward speed of the distributor truck.

Spray Bar Adjustments

For normal use, the spray bar of the distributor should be adjusted, so the vertical axes of the nozzles are perpendicular to the roadway. Also, each nozzle on the spray bar should be set at the same angle. The angle set for each should be between 15 degrees to 30 degrees of the horizontal axis of the spray bar (fig. 16-34) or according to manufacturer's specifications. This action prevents the fan-shaped spray patterns of the nozzles from interfering with each other.

Another adjustment that is essential for uniform prime or tack coat coverage is the adjustment of the height of the spray bar. As shown in figure 16-35, the fan-shaped spray patterns from the nozzles overlap to different degrees, depending on the distance between the spray bar and the surface to be covered. The spray bar should be set high enough, usual] y 10 to 12 inches above the roadway for the surface to receive triple

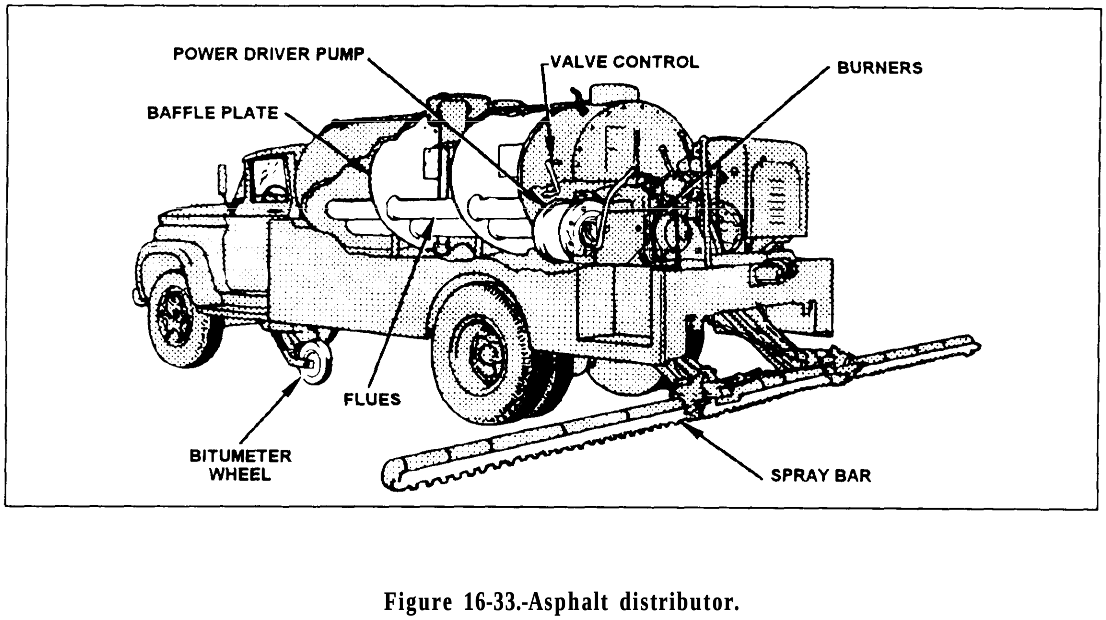
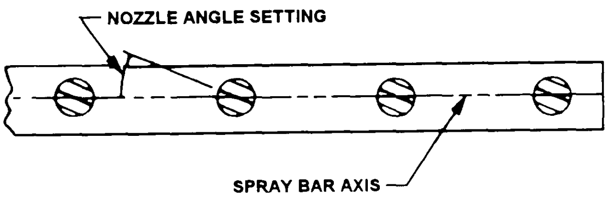


Figure 16-33.-Asphalt distributor.



NOTE: Some operators will set the end nozzles at different angles, such as 60 to 90 degrees with respect to the spray bar, in an attempt to obtain a good edge. This practice should NOT be premitted as it produces a fat streak on the edge and robs the adjacent spray fan of the lap from the nozzle. A curtain installed on the end of the spray bar, or a special end-nozzle with all the nozzles set at the same angle will provide more uniform coverage and produce a better edge.

Figure 16-34.-Proper angling of nozzles.

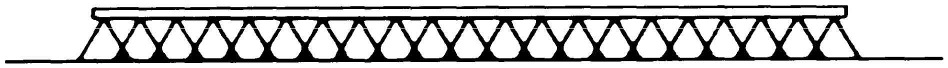
coverage. This height varies according to the nozzle spacing of the spray bar. Under heavy wind conditions or depending on the nozzle spacing, it maybe necessary to lower the bar farther down so that the surface only receives double coverage.

On some distributors, as asphalt is sprayed (and the load lightens), the truck rear springs of the truck rise, raising the distributor and changing the height of the spray bar. Mechanical devices are usually available that automatically correct the height of the spray bar, as this change occurs.

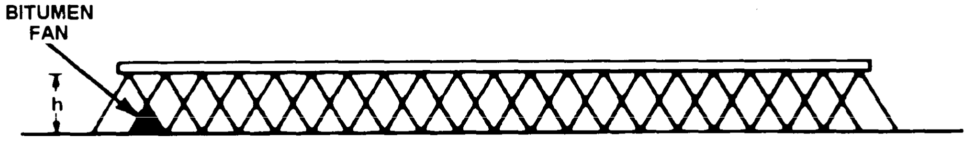
The uniform application of asphalt prime and tack coat is essential. Transverse spread should not be allowed to vary more than 15 percent, and the longitudinal spread should not vary more than 10 percent. To ensure the correct application, you must calibrate the distributor before it is used. Then the transverse and longitudinal spread rate variations should be checked periodically to determine when the distributor is operating within these limits. A procedure for checking these spread variations in the field has been standardized by ASTM D 2995, published by the American Society for Testing and Materials.

FILLING TANKS AND DISTRIBUTORS.— Always use a manhole strainer when filling tanks and distributors unless you are filling them with emulsions. When you do not want material to enter the pump and circulating system, ensure the intake valve lever is in the UP position. When the tank is full of hot bitumen that may set upon entering a cold pump, you should heat the pump and circulating system before starting to circulate the bitumen to prevent it from freezing in the pump. A portable burner is available to use if the pump is cold.

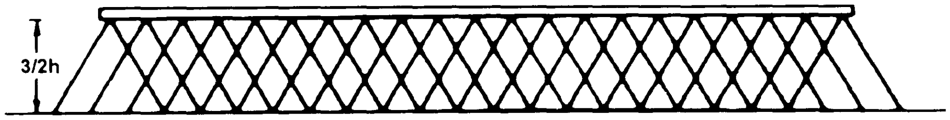
When you are filling lines using a pump, always use a strainer in the filling line except when using emulsions. Be sure that all connections between the distributor and source of supply are tight. Because air leaks reduce vacuum and slow down the heavier bitumens, it may be



INCORRECT SPRAY BAR HEIGHT



CORRECT SPRAY BAR HEIGHT-DOUBLE COVERAGE



CORRECT SPRAY BAR HEIGHT-TRIPLE COVERAGE

Figure 16-35.-Spray bar height and coverage.

necessary to preheat the circulating system to ensure that the first material to enter the pump is not to be chilled sufficiently to stop the pump. A portable burner is available for this purpose. An opening in the circulating system housing at the rear, near the bottom of the housing, is provided for the burner.

Normally, 150 gallons per minute (gpm) is the best loading speed. Light materials or heavy materials at spraying temperature may be loaded at faster pump speeds. Check the filling line as well as the pump discharge strainer periodically and clean as needed.

When the distributor is to be filled with hot bitumen, proceed cautiously if there is any moisture in the tank or if emulsion was used in the previous load because foaming could occur. A liquid compound, Dow Corning DC-200, can be used to prevent foaming.

HEATING BITUMEN IN THE DISTRIBUTOR.— When you are heating bitumen in a distributor with low-pressure atomizing burners, using clean, moisture-free fuel is important; therefore, use kerosene, fuel oil, or diesel fuel. **DO NOT USE GASOLINE.** To start the blower, disengage the engine clutch, engage the blower drive clutch, then engage the engine clutch.

Air pressure should be sufficient to raise the air relief valve slightly. Excessive engine speed will raise the relief valve too much. The correct air pressure to use is 1 1/2 to 2 psi.

Fuel pressure should not be excessive. High fuel pressure will make the needle valve adjustments more sensitive. The correct fuel pressure to use is 10 to 20 psi. Pressure is determined by a relief valve, located under the fuel tank. An adjusting screw and locknut are inside the dome-shaped cap.

Do not light the burners unless you are sure the flues are covered with 6 inches of material the full length of the tank. On tanks having high-low flues, it is necessary to cover only the lower flue when using the lower burner. Open the stack cover.

To light the burners, you should turn the air butterfly valves to the START position, light the torch, and hold it under the burner tip. Then turn the valve about one-half turn. The burner should ignite immediately. If it does not, turn off the needle valve and wait until the gas is exhausted from the flues, then try again.

NOTE: The correct amount to turn the needle valve is determined by the fuel pressure. Experience is the only way you can determine the correct amount for a particular unit.

At first, the flame will be yellow and smokey. Adjust the fuel valve so that the flame is bright orange with slight color in the exhaust. More adjustment to the fuel will be needed as the flues and tank contents heat up.

WARNING

> When the burner goes out, you should turn off the fuel valve immediately and do NOT attempt to relight until the gas vapors are exhausted from the flues.

For larger flames, increase the air butterfly valve opening and the fuel valve opening in equal increments. Always keep a mix that produces an exhaust that has a slight color. The nozzle of the burner is adjustable for the amount of secondary air desired. Light the burner and turn this nozzle until you secure the type of flame you desire. Further adjustment is not necessary. Do NOT leave the burners unattended. Do NOT heat to a temperature over the maximum spraying temperature recommended by the supplier. To shut off the burners, turn the fuel off before stopping the blower or turning off the air.

Spraying

Correct spraying cannot be obtained unless the bitumen is heated to the proper spraying temperature. When using 1/8-inch nozzles, set the governor from 120 to 180 gpm for a 12-foot spray bar. In the NCF, a rule of thumb for GPM is 10 gallons per minute for every foot of bar length. Example: 10-foot bar length = 10 GPM. Higher pump speeds cause excessive fogging of the spray. Lower pump speeds cause the bitumen spraying fan, as shown in figure 16-33, to sag with heavy edges. Also, when the fans have heavy edges, the cause could be that the material is too cold or the pump speed is too slow.

At the end of the day, be sure to flush out the pump and circulating system. Performing this easy draining and cleaning operation prevents the pump and circulating system from clogging up because of bitumen setting up and hardening in the system.

Attachments

Some areas cannot be reached with the spray bar; therefore, it is sometimes necessary to apply asphalt by another means. In such cases, spraying can be done by hand with a spray hose and gun, as shown in figure

16-36. This equipment must be operated following the instructions, given in the manufacturer's manual.

Suggested Spraying Temperatures

Suggested spraying temperatures are given in table 16-3 for various types and grades of asphalts commonly used for prime coating and tack coating.

WARNING

Application temperatures may, in some cases, be above the flash points of some materials. Care must be given to prevent fire or explosion. The maximum temperature (cutback asphalt) shall be below that at which fogging occurs.

Below are the formulas used for distributor truck operations.

To compute gallons per minute (GPM):

$$GPM = \frac{L \times Bar\ Width \times ROA}{9}$$

Table 16-3.-Suggested Spraying Temperature Ranges for Prime and Tack Coat

Type and Grade of Asphalt	Temperature
SS-1	70°F - 160°F
SS-1h	
CSS-1	70°F - 160°F
CSS-1h	
MC-30	85°F+
MC-70	120°F+
MC-250	165°F+

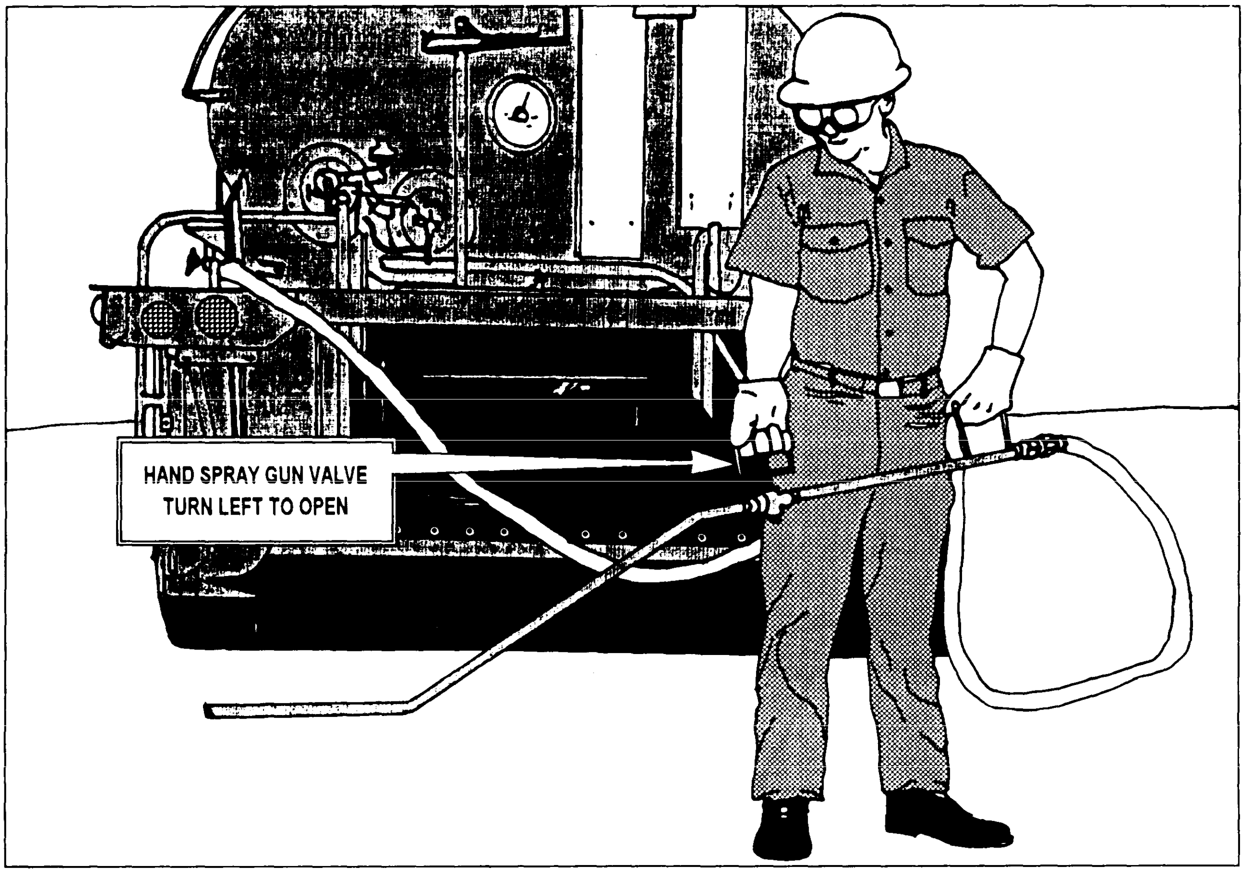


Figure 16-36.-Hand-spray application.

To compute truck application speed in feet per minute (FPM):

$$FPM = \frac{9 \times GPM}{Bar\ Width \times ROA}$$

To compute truck application speed in miles per hour:

$$MPH = \frac{9 \times GPM}{88 \times Bar\ Width \times ROA}$$

To compute the length of spread in feet:

$$L = \frac{9 \times T}{W \times ROA}$$

Where

L = Length of spread in feet

T = Total gallons in distributor

W = Sprayed width of roadway in feet

ROA = Rate of application in gallons per square yard.

ASPHALT KETTLE

The asphalt kettle shown in figure 16-37 is equipped for hand-spraying bituminous materials for dressing stretches of road or runway shoulders, filling surface cracks, and spray-coating areas for asphalt repairs, surface treatment, or seal coating.

The trailer-mounted tank consists of an outer shell with a 165-gallon capacity storage and melting tank mounted inside. A removable fuel burner, mounted inside the kettle outer shell, provides heat to the melting tank through a baffle. A flue stack located on the forward end of the melting tank over the top of the baffle and burner assembly, provides an escape for exhaust gases. A thermometer, inserted through an insulated pipe into the interior of the melting tank indicates the temperature reading of the bituminous material being heated. When the bituminous material is overheated, a fire or explosion can result.

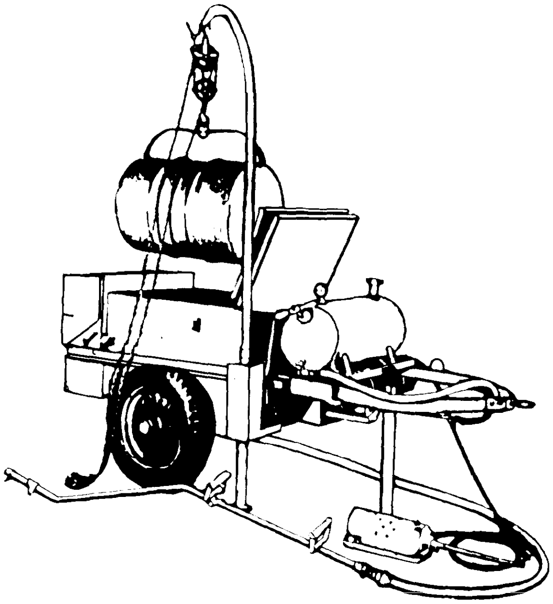


Figure 16-37.—Asphalt kettle.

A two-cylinder gasoline engine provides power for the bitumen pumping system. When you shift the clutch shifter lever, the engine is engaged to the pump assembly that provides the pressure for all pumping operations. A flexible, metal spray hose, which connects the pump to the hand-held spray bar assembly, is used to convey bitumen to the surface being repaired.

SAFETY PRECAUTIONS

Safety precautions for the distributor truck and asphalt kettle operations are as follows:

- Always have dry chemical type of extinguishers available and in good condition.
- Check all body mounting tie-downs and fasteners. On trailer units, check kingpin plate fasteners and all suspension and running gear components.
- Lighted cigarettes or other sources of combustion must be kept clear of open manholes or overflow vents to reduce fire hazards.
- Sparks from the engine exhaust can be for the ignition of volatile gases.
- Remain clear of rotating drives when the unit is in operation to prevent becoming entangled in the machine.
- Use goggles and gloves or insulated material when handling the spray bar, sections, or hoses to prevent burns.
- Monthly, check (and if necessary clean) the 3-inch overflow tube to ensure that the tube is not clogged.
- Open a manhole slowly to relieve any pressure that may exist in the tank.
- Check and ensure that all pipe and hose connections are secure before operating valves to eliminate leaks (that may spray hot bitumen on other personnel).
- Keep the unit clean for safety and operation.

- Keep the area clear of open flame or sparks to reduce fire hazard when you are spraying material with volatile cutbacks.

- Do not stand in a location in which the accidental opening of the spray bar valves will cause contact with the bitumen spray. This is important, because you could receive serious burns if you do not.

- The fill line cap or connection must be securely attached before operating the intake valve lever to eliminate momentary discharge.

- The "TUC" bar must be off and remain off when the bar is rotated upward.

- When moisture is present in the tank, do not load the tank with material having a temperature over 200°F. To prevent foaming when filling a unit in which moisture may be present in the spray bar or the circulating system, you should allow a small portion of hot material to circulate in the spray bar before filling the tank.

- When you are heating material, if at all possible, position the unit broadside to the wind.

- The use of gasoline instead of regular kerosene or fuel oil on low-pressure burners will result in an extreme fire hazard.

- Do not operate burners unattended (unless a safety control is provided) or while the vehicle is in transit or in a confined area.

- When heating, you must allow sufficient space in the tank for expansion of the material.

- To prevent a possible explosion, you must cover flues with at least 6 inches of bitumen before heating the material, This layer of bitumen reduces the vapors produced, thereby, reducing the chance of an explosion.

- For personal safety, use a torch (not a match or lighter) to ignite the burner.

- Ignite the inside burner first. Do not reach across a lighted burner to ignite the inside burner.

- When burners go out, allow time for ventilation before re-ignition.

- Do not heat material beyond the manufacturer's recommended temperature.

- When you are hand spraying, hold the sprayer in the proper position and be aware of other personnel in the area.

- Emulsified asphalts should never be left in the distributor truck for any great length of time. Emulsified asphalts will separate and set in much less time than will cutbacks.

- Avoid inhaling the vapors or mist from sprayed asphalt, or prolonged skin contact with asphalt products. Asphalt materials contain compounds known or suspected to causes cancer. Hot asphalt is a bum hazard and can cause serious eye damage.

ASPHALT HAUL TRUCKS

Various types of trucks are used to deliver hot mix to the paver. The most common type is the 5-ton end-dump truck but other trucks have been used and can be used to deliver mix.

Truck Condition

Trucks must have metal beds, and the beds must be clean, smooth, and free of holes. All trucks must meet minimum safety criteria. Each truck must be clearly numbered for easy identification and must be equipped with a tarpaulin.

Before being loaded, the truck bed must be cleaned of foreign material and hardened asphalt and then lightly coated with a release agent (lubricant) that assists in preventing fresh hot-mix asphalt from sticking to the surfaces of the bed. After the bed is coated, any excess release agent must be drained from the bed. Before loading, the truck must also be weighed to establish its unloaded weight. This weight is later subtracted from the loaded weight of the truck to determine the weight of the hot mix that the truck is hauling.

The number of trucks required on the project is determined by many factors: the mix production rate at the plant, the length of the haul, the type of traffic encountered, and the expected time needed for unloading.

Types of Trucks

Each type of truck used for hot-mix delivery must have certain physical features that are required to haul properly and to discharge the mix properly into the paver. Below are listed a few guidelines for the two most common types of trucks.

END-DUMP TRUCKS.— An end-dump truck must first be inspected to be certain the rear of the bed overhangs the rear wheels enough to discharge mix into the paver hopper. If it does not, an apron with side plates must be added to increase the overhang and prevent spillage of the mix in front of the paver.

The bed must also be of a size that will fit into the hopper without pressing down on the paver. The hydraulic system for the truck-bed hoist should be frequently inspected to guard against hydraulic fluid leakage. Such leakage on the roadway surface will prevent good bonding between the roadway and the new mat. When enough oil is spilled that the mix can absorb it, the mix can become unstable at that spot. For this reason, leaking trucks should not be used.

Tarpaulins should be pulled over the mixture during hauling in cool weather or on long hauls to protect the mixture from excessive cooling. A cool mix forms lumps and a crust over its surface. When a tarpaulin is used, care must be taken to be sure it is securely fastened to the top of the truck bed so that cold air cannot funnel under it.

During delivery, the driver must direct the truck squarely against the paver and should stop the truck a few inches from the paver before the truck tires make contact with the paver roller bar. Backing the truck against the paver can force the screed back into the mat, leaving a bump in the pavement even after the mat is rolled.

The truck bed must be raised slowly. When the mix is dumped too rapidly, segregations occur, because the coarser aggregates will roll down the sides of the load.

BOTTOM-DUMP TRUCKS.— Bottom-dump trucks can be used when a grader is spreading the mix or when a pickup device is used to feed the windrow left by the truck into the paver hopper.

Two common methods for unloading bottom-dump trucks are in use. The first method involves the use of a spreader box, designed to be operated under the gates of the truck. The amount of material, placed in the windrow, is governed by the width of the spreader box opening. The disadvantage of this method is that the spreader box can restrict the amount of material to less than the required amount. The second method, which is used more often than the first, is to use chains to control the dump gate opening.

NOTE: Automatic devices are also available for controlling gate openings.

Variations in the size of the windrow, deposited by the bottom-dump truck for pickup by the paver, and irregularities in the surface on which the material is to be placed will cause variations in the amount of material fed to the paver hopper. This often causes variations in the finished surface. It is, therefore, essential that the windrow, deposited by the truck be as uniform as possible. When the windrow is deficient in size, material can be added to it to keep the paver from starving. When the windrow contains too much mix, a short gap in depositing with the next truck will compensate for the excess. The windrow length must also be controlled particularly in cool weather. Windrowed material will cool below spreading and compaction temperatures in cool weather, particularly when delay occurs because of paver malfunction. The limit of the windrow should be no more than one truck load ahead of the pickup machine to prevent excessive cooling of the mix in cold weather.

When the loader and paver are directly coupled, vibration of the pickup device maybe transmitted into the paver, causing ripples and roughness in the mat surface. These vibrations generally result from worn and defective parts or from improper mounting or adjustment.

Truck Hitches

The purpose of a truck hitch on the front of the paver hopper is to keep the truck dumping hot mix into the hopper in contact with the paver. If, during dumping, the truck and the paver separate and hot mix spills, it must be cleaned up before the paver passes over it.

Two types of truck hitches are in common use. One type uses an extension that reaches under the truck and hooks onto the rear axle of the truck. The other type of hitch has retractable rollers that are attached to the truck push bar and grip the outer side of the rear wheels of the truck. The rollers revolve with the wheels while the truck dumps its load into the hopper.

Pivoted Truck Push Rollers

The pivoted push roller is a device, mounted on the front of the paver, that adjusts when alignment between the truck and paver is uneven. This device reduces the uneven force exerted on the paver by the misaligned truck, minimizing interference in the steering of both vehicles.

ASPHALT FINISHERS (PAVERS)

Various makes and models of asphalt finishers are used by the Naval Construction Force (NCF). Two types are shown in figure 16-38. Even though the finishers may operate differently, their primary jobs are all the same: receiving asphalt and spreading it in a predetermined, uniform length, width, thickness, and shape. The finisher also provides initial compaction of the mat (layer of mixture in place.)

Because asphalt finishers are different, you must always read the operator's manual for the unit you are operating. It is also good to have a practice sand laydown before actually using a hot mix. This is to familiarize yourself and others with the machine and also ensure that the machine is working properly. Figure 16-39 shows a practice laydown, using just the aggregate mix without the asphalt.

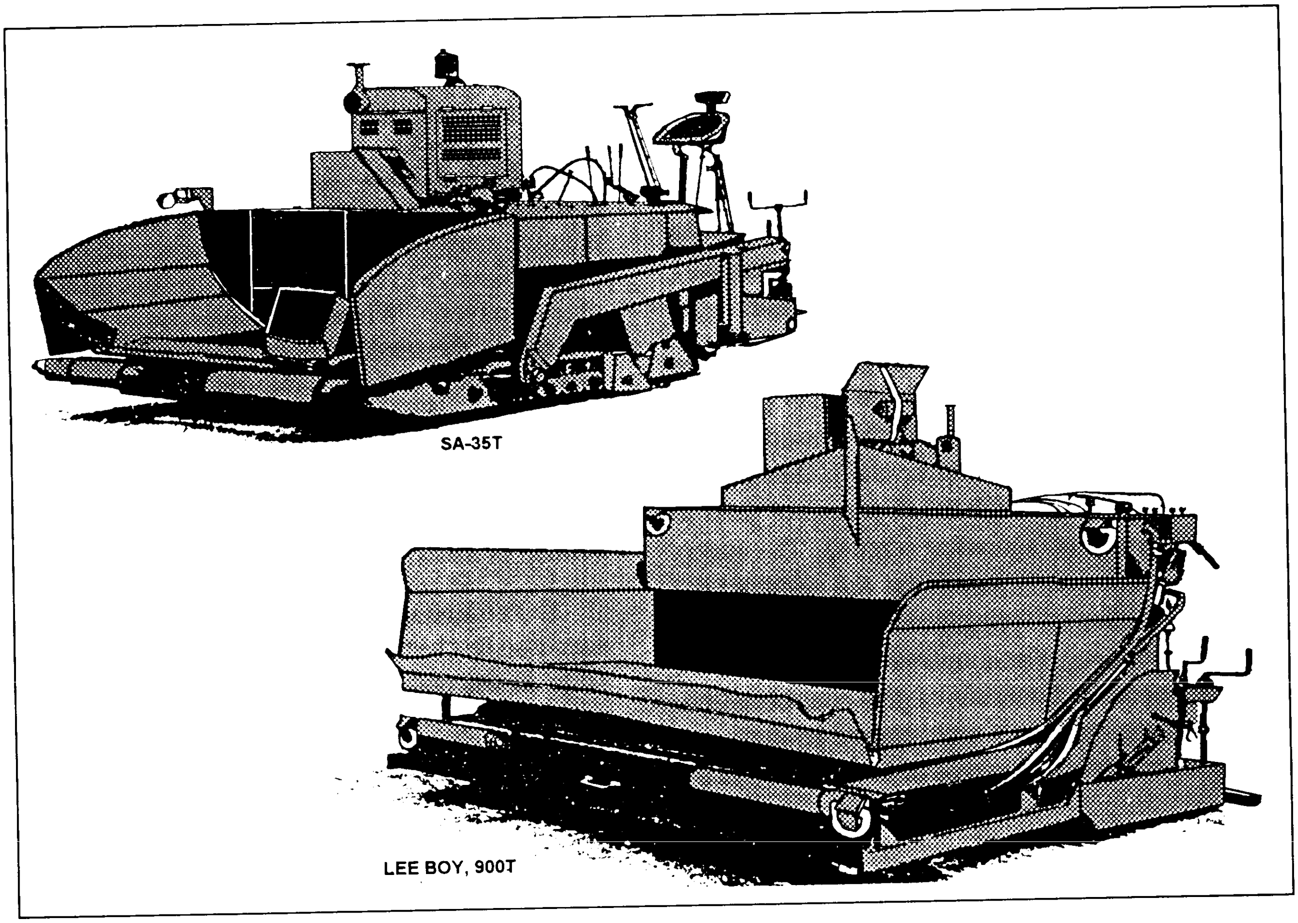

SA-35T
LEE BOY, 900T

Figure 16-38.-Two common types of asphalt finishers.

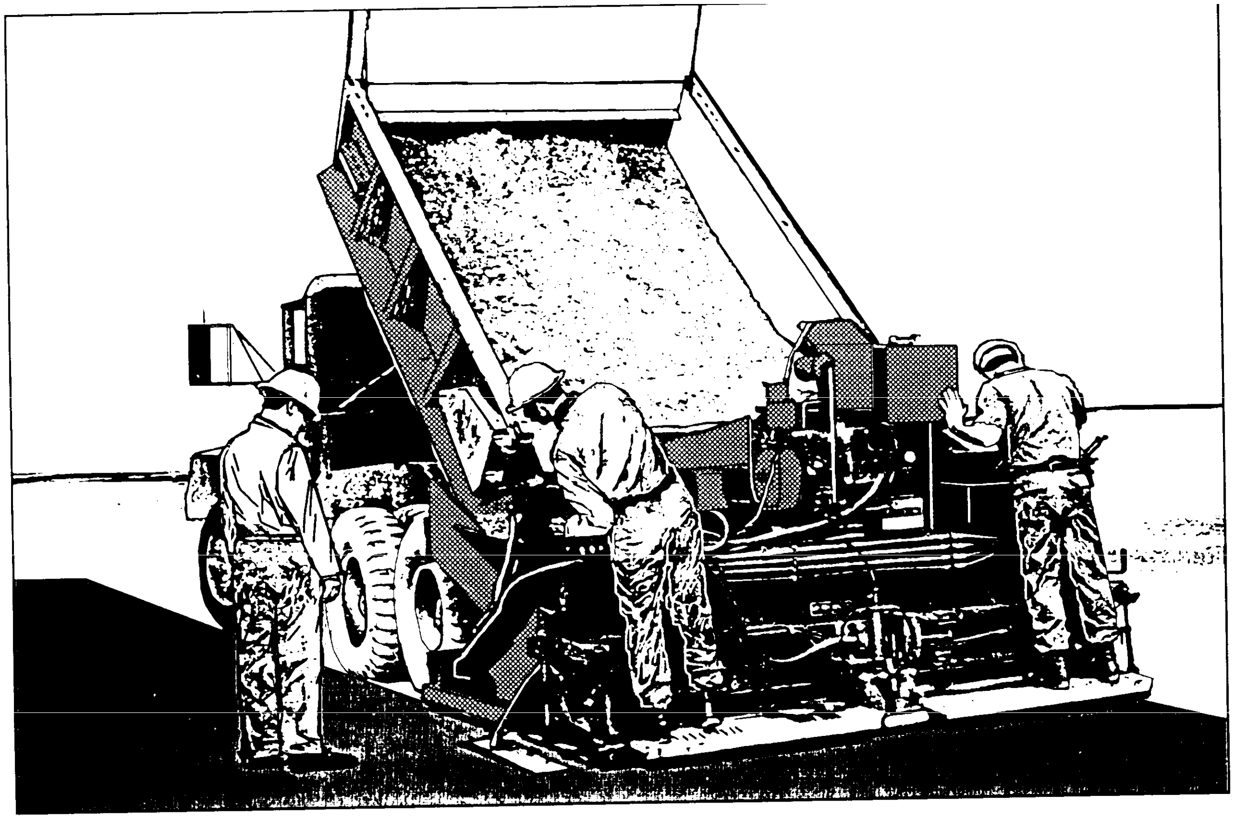


Figure 16-39.—Practice laydown.

Tractor Unit (Power Unit)

The tractor unit provides moving power for the paver wheels or tracks and for all powered machinery on the paver. The tractor unit includes the receiving hopper, feed conveyor, flow control gates, distributing augers (or spreading screws), power plant (engine), transmissions, dual controls, and operator's seat.

The tractor unit power plant (engine) propels the paver, pulls the screed (leveling) unit, and provides power to the other components through transmissions. Hot mix is deposited in the hopper and is then carried by the feed conveyor through the flow control gates to the distributing augers (spreading screws). The augers distribute the mix evenly across the full width of the paver, thus providing uniform placement of the mix onto the roadway surface. These operations are controlled by the paver operator by means of dual controls within easy reach of the operator's seat. Figure 16-40 shows the operating controls of one type of finisher used in the NCF.

To ensure the paver functions properly, you should inspect the paver before commencement of paving. Below are some of the compments you should check.

PAVER TIRES OR TRACKS.— When the paver is equipped with pneumatic tires, tire condition and air pressure must be checked. It is particularly important for the pressure to be the same in the tires on both sides of the paver. When the paver moves on tracks (crawlers), the tracks should be checked to be certain they are snug but not tight, and the drive sprockets should be checked for excessive wear. Low tire pressure or loose tracks can cause unnecessary movement of the paver, which is transmitted to the screed unit, resulting in an uneven pavement surface. There should be no buildup of material on the tires or on the tracks.

GOVERNORS.— The governor on the engine must also be checked to be sure that there is no periodic surge in the engine rpm. When the governor is not working properly, there can be a lag in power when the engine is loaded (strained). Such a lag causes temporary failure of the vibrators or tamping bars in the screed unit, resulting in a stretch of pavement that is less dense or

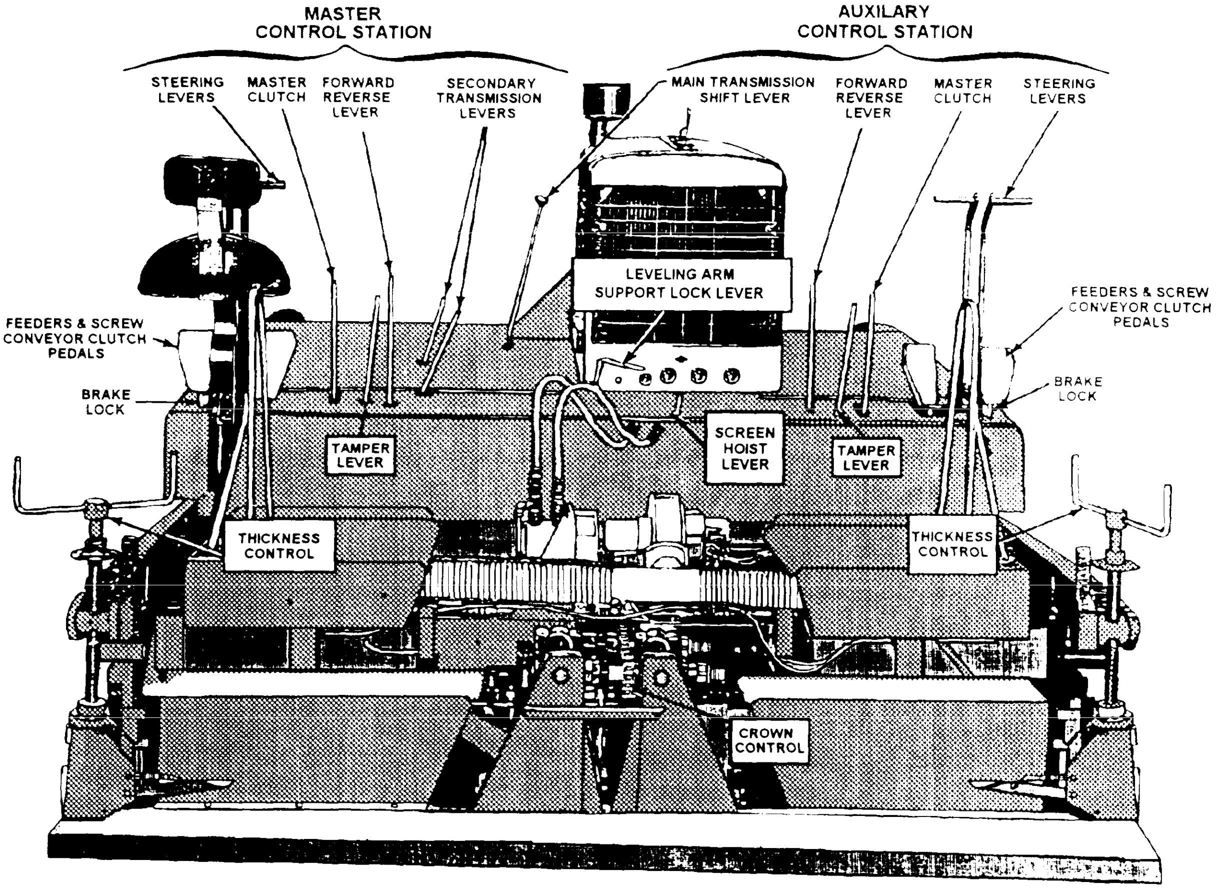

MASTER CONTROL STATION
AUXILARY CONTROL STATION
STEERING LEVERS
MASTER CLUTCH
FORWARD REVERSE LEVER
SECONDARY TRANSMISSION LEVERS
MAIN TRANSMISSION SHIFT LEVER
FORWARD REVERSE LEVER
MASTER CLUTCH
STEERING LEVERS
LEVELING ARM SUPPORT LOCK LEVER
FEEDERS & SCREW CONVEYOR CLUTCH PEDALS
FEEDERS & SCREW CONVEYOR CLUTCH PEDALS
BRAKE LOCK
BRAKE LOCK
TAMPER LEVER
SCREEN HOIST LEVER
TAMPER LEVER
THICKNESS CONTROL
THICKNESS CONTROL
CROWN CONTROL

Figure 16-40.-Operating controls, Barber-Greene model SA-35 finisher.

contains slightly less material than the immediately adjacent area. After rolling, you can see that an area shows up as a transverse ripple in the pavement. A power lag can also interfere with the smooth and consistent operation of the electronic screed controls.

HOPPERS, FLOW GATES, AND AUGERS.— The hopper, the slats on the feed conveyor, the flow gates, and the augers should be checked for excessive wear and observed to be certain they are operating properly. Necessary adjustments should be made to ensure that these components are functioning as designed and are able to deliver a smooth flow of mixture from the hopper to the roadway. This includes adjustments to any automatic feed controls.

The speed of the conveyor and the opening of the control gates at the back of the hopper should be adjusted, so just enough mixture is being delivered to the augers to keep the augers operating about 85 percent of the time.'This allows a uniform quantity of mix to be maintained in front of the screed.When additional mix is required to allow an increase in the thickness being placed, the flow control gates should be adjusted. Augers should be kept about three-quarters full of mixture during paver operations.

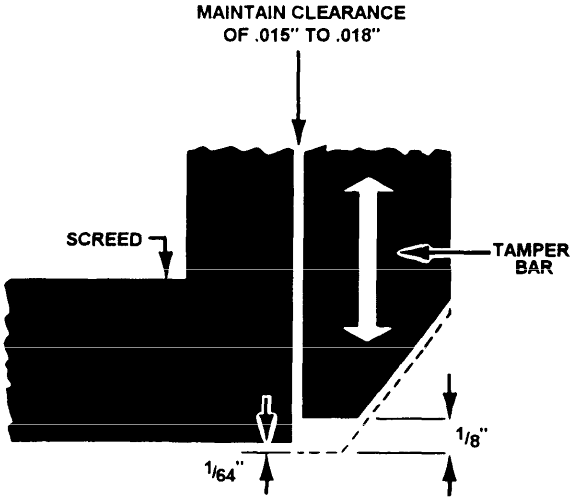


Figure 16-41.-Tamping bar.

Screed Unit

In operation, the screed is pulled along behind the tractor unit. The long screed pull-arms are pivoted that permits the screed to have a floating action, as it travels along the road. As the tractor unit pulls the screed into the mix, the screed seeks the level that allows the path of the screed to be parallel to the direction of pull. At this level, all of the forces, acting on the screed, are in balance, as the paver moves down the road. The screed plate irons the surface of the mixture, leaving the mat thickness at a depth that conforms with job specification. Mat thickness and crown shape are regulated by screed controls. Tamping bars (fig. 16-41) or vibratory attachments then compact the mat slightly in preparation for rolling. Figure 16-42 shows the workings of a screed.

Attaining proper mat thickness is a matter of balancing the forces, as shown in figure 16-42, with one another.

1. To maintain forward motion of the screed, force P must be greater than force H.

2. To increase the thickness of the mat, tilt the screed plate so that more material is crowded under the screed plate. The screed will rise until the finished surface is again in a plane parallel to the direction of pull.

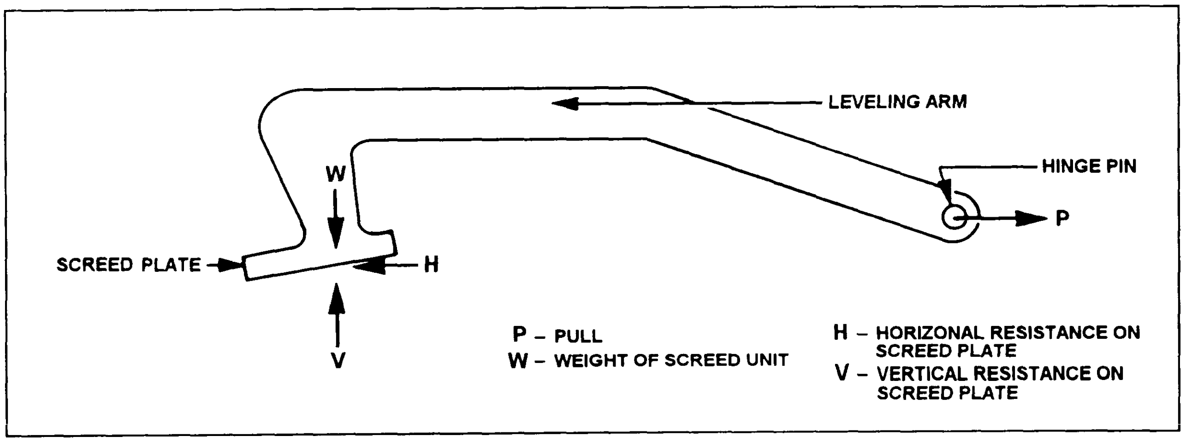

LEVELING ARM
HINGE PIN
P
W
SCREED PLATE
H
V
P - PULL
W - WEIGHT OF SCREED UNIT
H - HORIZONAL RESISTANCE ON SCREED PLATE
V - VERTICAL RESISTANCE ON SCREED PLATE

Figure 16-42.-Forces acting on the screed.

Force V will decrease at this point and be balanced by force W.

3. To reduce mat thickness, tilt the screed plate so that less material crowds under the screed plate.

4. The amount and condition of the material, leaving the auger, can change the equilibrium of the four forces. Excessive flow of material increases force H. A cold, stiff mix will increase H and to some extent V. An excessively hot, fluid mix decreases H and V. Stopping and starting the paver also cause changes in equilibrium among the forces. The key to controlling the action of the screed is to maintain in a uniform manner those forces acting on the screed.

5. The secret of good paver operations is a balance of the forces and uniformity to maintain that balance. When balance and uniformity are attained, the screed path follows the paver in a plane parallel to that of the pivot point. As the paver goes up over an irregularity, the pivot point rises and the screed begins to rise also. However, because the screed reacts to changes in elevation more slowly than the pivot point does, the screed rises very little and thereby maintains the plane of the surface of the mat over the irregularity, and the impact of the irregularity is reduced. The same is not true of long irregularities (longer than several lengths of the paver). Grade line irregularities of this type should be corrected before placing surface courses with the paver.

6. Screeds, equipped with tamping bars and vibratory mechanisms, are designed to strike off and then compact the mixture slightly, as it is placed. The two purposes for this screed action are that it achieves maximum leveling of the mat surface and ensures that minimum distortion of the mat surface occurs with subsequent rolling.

TAMPING BAR TYPES OF SCREEDS— Tamping bar types of screed compactors compact the mix, strike off the excess thickness, and tuck the material under the screed plate for leveling. As figure 16-41 shows, the tamper bar has two faces:

- A beveled face on the front that compacts the material, as the screed is pulled forward.

- A horizontal face that imparts some compaction, but primarily strikes off excess material, so the screed can ride smoothly over the mat being laid.

The adjustment that limits the range of downward travel of the tamping bar is the single most important adjustment affecting the appearance of the finished mat. At the bottom of its stroke, the horizontal face should extend one sixty-fourth of an inch (about the thickness of a fingernail) below the level of the screed plate. When the bar extends down too far, mix builds upon the screed face. This buildup scuffs the surface of the mix being placed and also causes the tamping bar to lift the screed slightly on each downward stroke, and this often causes rippling of the mat surface.

When the horizontal face of the tamping bar is adjusted too high (either by poor adjustment or due to wear of the bottom of the horizontal face), the bar does not strike off excess mix from the mat. Consequently, the screed plate begins to strike off the material, and this results in surface pitting of the mix being placed because the leading edge of the screed plate drags the larger aggregates forward. For this reason, the tamper bar should always be checked before operating the paver, and it should be adjusted if necessary. Before the tamper bar approaches knife-edge thinness, it should be replaced.

VIBRATING TYPES OF SCREEDS.— The operation of vibratory screeds is similar to that of tamping screeds, except that the compactive force is generated either by electric vibrators, rotating shafts with eccentric weights, or hydraulic motors (fig. 16-43).

On some pavers both the frequency (number of vibrations per minute) and the amplitude (range of motion) of the vibrators can be adjusted. In others, the frequency remains constant and only the amplitude can be adjusted. Frequency and amplitude must be set according to the type of paver, the thickness of the mat, the speed of the paver, and the characteristics of the mixture being placed. Once set, the frequency and amplitude do not normally need adjustment until the mat thickness or mix characteristics change.

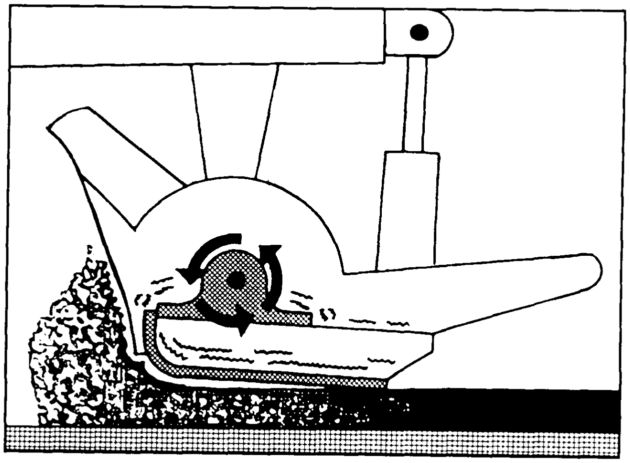


Figure 16-43.-Vibratory type of screed.

Some vibratory screeds require a pre-strike-off unit. This unit is a rounded moldboard that controls the amount of mix passing under the screed.

SCREED CONTROLS (ADJUSTMENTS).— In operating the screed, two types of controls are essential:

- Control of the thickness of the mat
- Control of the crown, formed in the mat for proper drainage

Both functions are regulated by controls built into the paver (fig. 16-44).

It is important to understand that, when the paver is operating, control adjustments, made to the screed, take time to go into effect. For example, when a thickness control screw is adjusted to change the thickness of the mat, the paver is likely to move a distance of several feet before the change is completed, and the mat is produced in the new thickness. For this reason, it is necessity that a screed operator know the effective delay involved in making adjustments to a particular screed unit and be able to anticipate adjustments accordingly. Furthermore, it is important that after such adjustment of the thickness controls, the paver be allowed to travel far enough for the correction to be completed before another adjustment is made. Excessive adjustment or overcontrol of the thickness controls is one of the principal contributors to poor pavement smoothness.

The condition of the screed unit is important when a high-quality mat is to be placed. To ensure the screed control linkage is snug, the operator should check the wear points. Also, the screed plates should be checked regularly for signs of wear, such as pitting and warping. The plates should always be properly adjusted before paving begins. Both the leading and trailing edges of the screed have a crown adjustment. The leading edge should always have slightly more crown than the trailing edge. This provides a smooth flow of material under the screed. Too much lead crown results in an open texture along the edges of

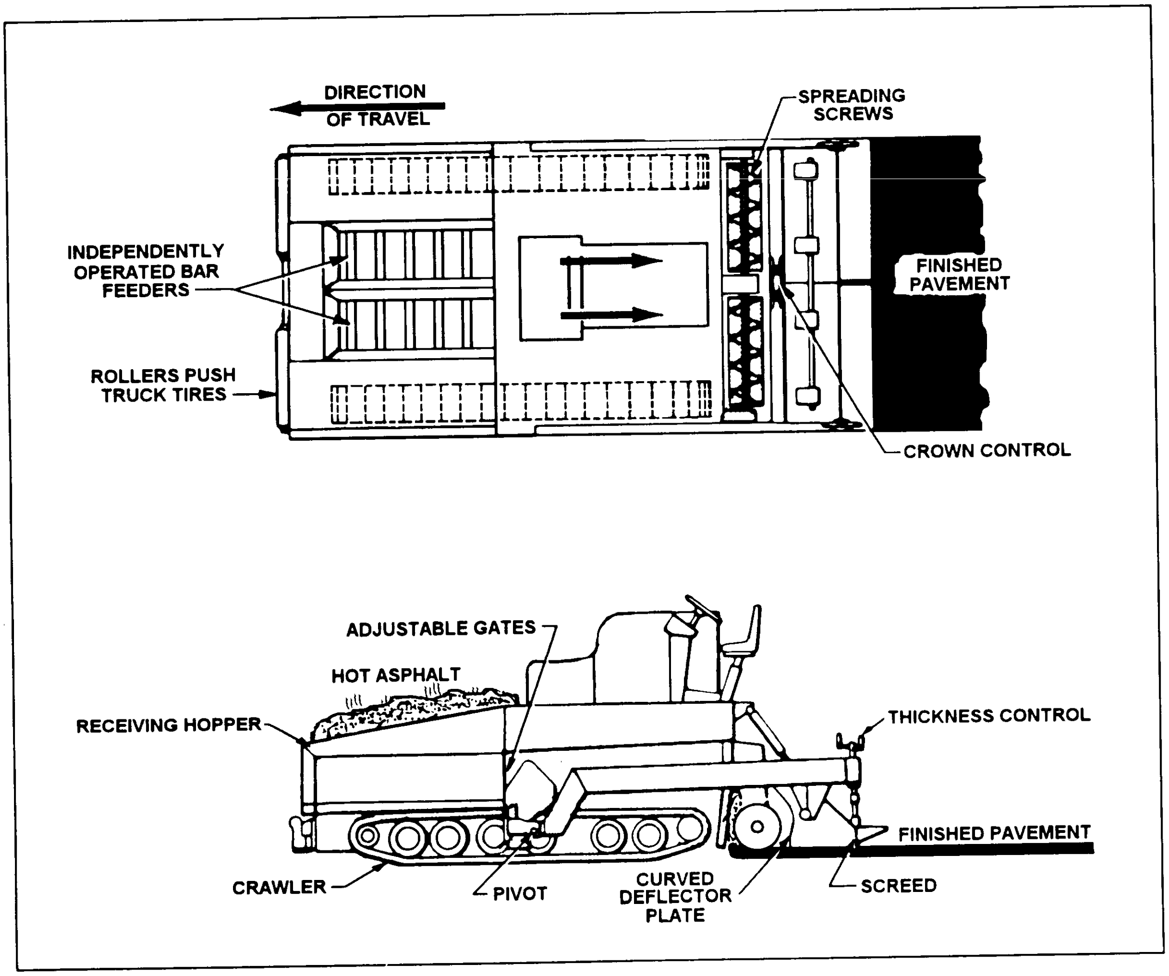

DIRECTION OF TRAVEL
SPREADING SCREWS
INDEPENDENTLY OPERATED BAR FEEDERS
FINISHED PAVEMENT
ROLLERS PUSH TRUCK TIRES
CROWN CONTROL
ADJUSTABLE GATES
HOT ASPHALT
RECEIVING HOPPER
THICKNESS CONTROL
FINISHED PAVEMENT
CRAWLER
PIVOT
CURVED DEFLECTOR PLATE
SCREED

Figure 16-44.-Mat thickness and crown controls.

the mat and too little results in an open texture in the center. The trailing edge is what actually sets the crown. Crown adjustments may be made independently or simultaneously during the paving operation.

AUTOMATIC SCREED CONTROLS.— The screed controls must be adjusted by the screed operator as paving progresses. Automatic screed controls are designed to adjust automatically to place a uniform mat of the desired thickness, grade, and shape (fig. 16-45).

Types and Operating Principles.— Automatic screed controls can be used in several different ways, but all automatic screed control operations require a reference system for the automatic system to follow. This reference system can be the base on which the asphalt hot mix is being placed, the lane next to the material being placed, or a string line. When a string line is used as a reference, the automatic control will follow the height of the string line exactly, so the mat conforms to it; therefore, placement of the string line (or other reference system) must be precise.

Automatic screed controls can also follow traveling reference systems. A traveling reference system, such as a ski attached to a control arm, notes changes in base contours and adjusts the screed automatically to compensate.

A string line or traveling reference system allows the automatic control to adjust screed height as necessary to maintain proper longitudinal (lengthwise) grade of the pavement. Automatic screed controls use a system, attached to a beam, running between the two screed pull-arms to maintain proper transverse (widthwise) grade.

A pendulum in the slope control housing moves side to side with changes in the transverse grade of the roadway, triggering necessary adjustments in the slope control mechanism.

Automatic control systems have several advantages over manually controlled screed systems. Some of the advantages are as follows:

- Automatic controls compensate for changes in grade and slope more quickly than a screed operator could.
- Automatic controls help disassociate the screed from the erratic vertical movement of the tractor unit.
- Automatic controls adjust the screed tow points to enable the screed to follow a path parallel to the grade and slope of the reference system, which may be different from the path plane of the tractor unit.

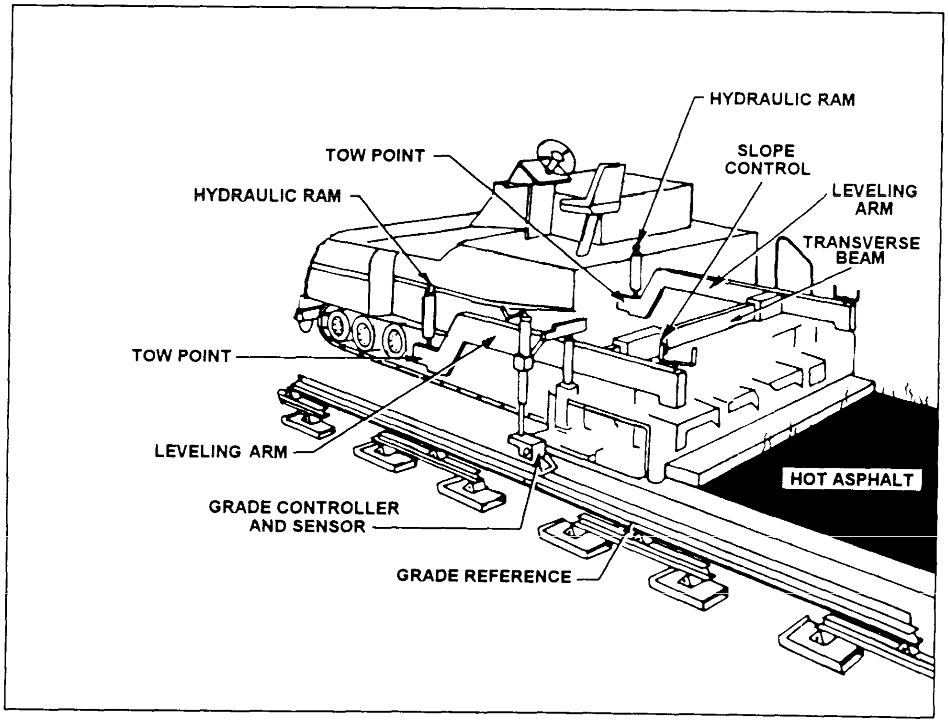


Figure 16-45.—Automatic screed reference system.

Selecting a Reference System.— Two types of reference systems, such as stationary or traveling, to use with an automatic screed control depend on the following factors:

- The condition of the surface on which the mat is to be placed.
- The degree of precision required in the grade and slope of the finished pavement.
- The thickness of the mat.
- The amount of material available for the project.

When the surface on which the mat is to be placed has a good longitudinal grade along its center line but has an unsatisfactory transverse grade, a traveling reference, run along the center line, can be used effectively to provide the desired mat thickness at the center line and the transverse slope control, used to establish the outside grade.

When the longitudinal grade is erratic, a string line should be placed to ensure a proper longitudinal grade. When the existing surface has a good profile both longitudinally and transversely, automatic screed controls may be unnecessary. The self-leveling ability of the screed may be sufficient. When automatic controls are used, a traveling reference system would be adequate.

SCREED HEATERS.— The screed is equipped with heaters, used to heat the screed plate at the start of each new paving operation. The heaters are not used to heat the mix during the paving operation. If the screed is not initially heated, the mix will tear and the texture will look open and coarse, as it would if the mix were too cold. There are times when the paver operator allows the mix to heat the screed plate. This practice almost always results in a section of unsatisfactory pavement being laid while the screed is being heated.

SCREED ACCESSORIES.— Three types of commonly used screed accessories are screed extensions, cutoff shoes, and bevel end plates.

Screed Extensions.— Screed extensions (fig. 16-46) are attachments that widen the screed, allowing the paver to place a wider-than-normal mat. On some

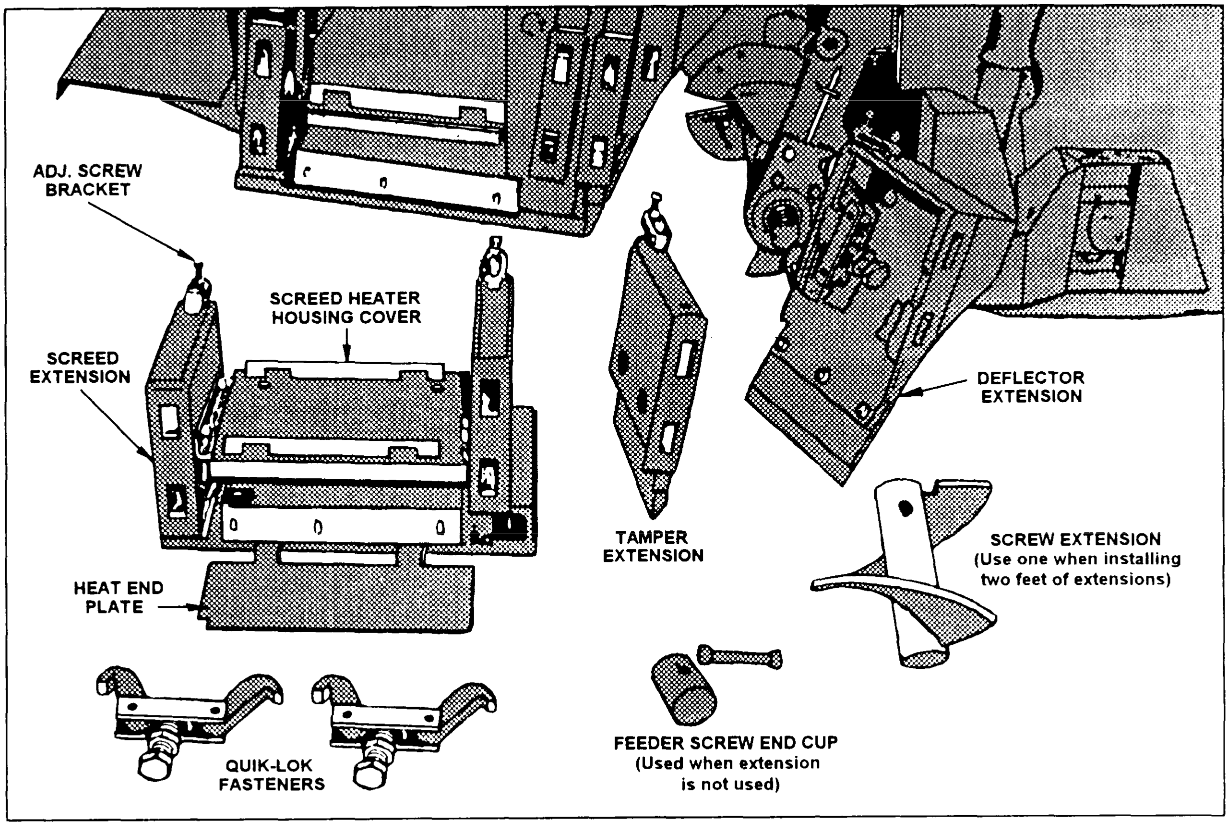

ADJ. SCREW BRACKET
SCREED HEATER HOUSING COVER
SCREED EXTENSION
DEFLECTOR EXTENSION
TAMPER EXTENSION
SCREW EXTENSION (Use one when installing two feet of extensions)
HEAT END PLATE
QUIK-LOK FASTENERS
FEEDER SCREW END CUP (Used when extension is not used)

Figure 16-46.-Screed extension accessories.

models, screed extensions make it possible to pave widths up to 24 feet in a single pass.

Cutoff Shoes. — Cutoff shoes (fig. 16-47) have the opposite function of screed extensions. They are metal plates inserted into the screed to reduce the width of the mat being placed.

Bevel End Plates.— Bevel end plates (fig. 16-48) are used to bevel the edge of the mat. On some models, the shoes can be set at any one of three positions: vertical, 30 degrees, or 45 degrees.

Tons Per Hour

The equation, used to compute the amount of asphalt that can be layed with a paver per hour, is as follows:

$$\text{Tons per hour} = \frac{L \times W \times D \times 146}{2{,}000} \times 60$$

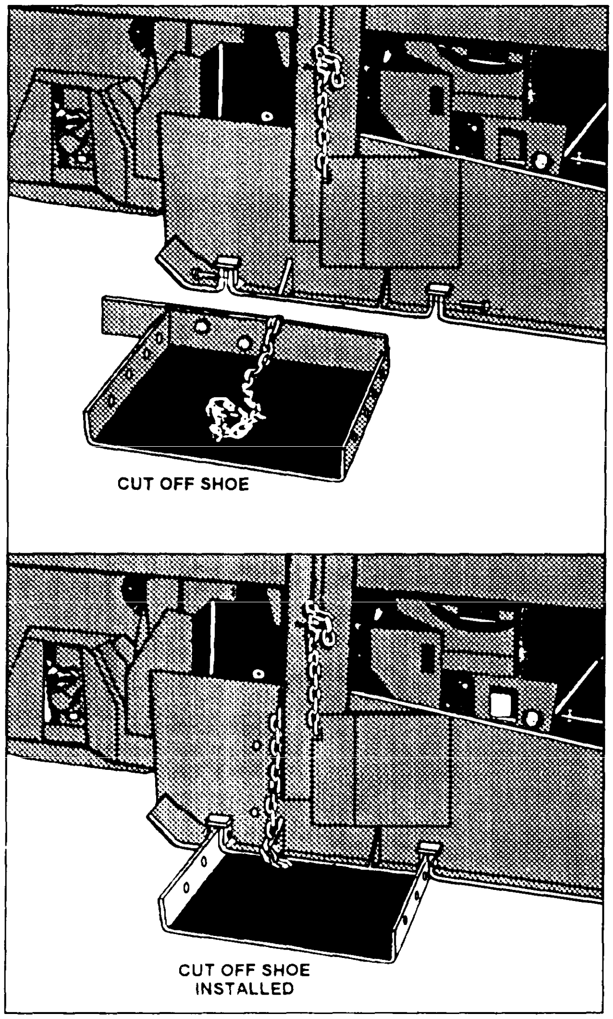


Figure 16-47.—Cutoff shoes.

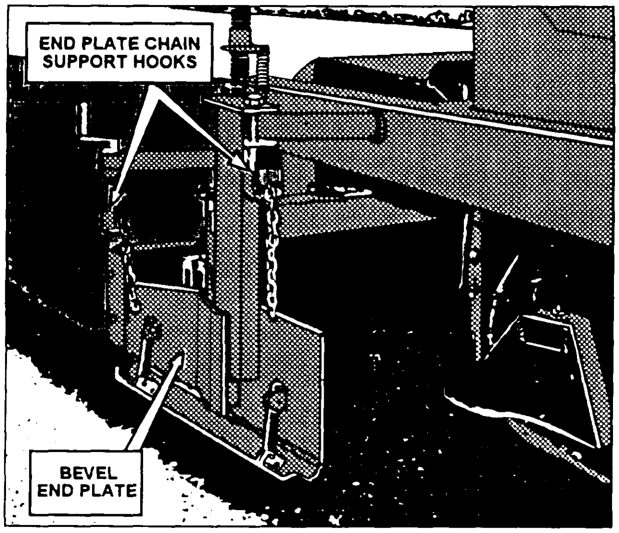


Figure 16-48.-Bevel end plates.

Where

L = Feet per minute. The NCF uses 11 feet per minute for planning purposes.

W = Width of the paver screed

D = Depth or thickness of compacted mat

146 = This number represents the approximate weight of 1 cubic foot of compacted hot-mix asphalt

60 = 60 minutes in 1 hour

2,000 = There are 2,000 pounds in 1 ton

Example: The required tonnage of hot-mix asphalt for a project is 800 tons. The screed of the paver is set at 10 feet, and the depth of asphalt is 2 inches. Estimate the amount of asphalt that can be laid per hour.

Solution:

$$\frac{11 \times 10 \times .167 \times 146 \times 60}{2{,}000} = \frac{160921.2}{2{,}000}$$

$$\frac{160921.2}{2{,}000} = 80.46 \text{ tons per hour}$$

By planning and estimating the amount of hot-mix asphalt that can be laid per hour, you are able to tell the asphalt plant exactly how much hot-mix asphalt is required to be delivered per hour or per day.

MAINTENANCE

As an Equipment Operator, it is your responsibility to coordinate the proper operation, care, use, adjusting, cleaning, preservation, and lubrication of paving and support equipment. This includes daily inspections and adjustments, required for good operation. Malfunctions in equipment, which go beyond those operating adjustments performed by the EO, should be referred to the field mechanic for corrective action. This does not release you from working with the field mechanic unless you are directed otherwise.

PAVING SAFETY

Construction with bituminous materials involves several hazards. One of the most serious dangers is associated with the heating required to convert the solid or semisolid materials to a degree of fluidity which will permit their application or mixing. As a safety measure, make sure fire-extinguishing equipment (foam type) is present at all times.

When readying the distributor and/or asphalt kettle, be sure they are in a level position (before heating) and are located a safe distance from buildings and other flammable materials. Keep covers closed during the heating period to prevent the escape of flammable vapors; avoid exposure to fumes from hot bituminous material-stay on the windward side. Wear gloves and full body clothing to avoid prolonged skin contact or burns from hot bituminous material.

When heating bituminous materials for spraying purposes, you should check the temperature suggested in table 16-2 for the type and grade being used. Remember that most of the flush points are exceeded before the materials reach spraying or working temperature; therefore, additional caution must be exercised to prevent the exposure of rising fumes to an open flame. A dense yellow cloud or vapor, rising from the distributor or kettle, is an indication that the material is being overheated to the extent that a small spark is sufficient to ignite the vapors.

Always extinguish burners before spraying bituminous material. When spraying, stand at least 25 feet clear of the spray bar. On a bituminous distributor, spray bars have been known to blow open or rip with sudden pressure of heated materials. Remember that bituminous material must be heated to a high temperature, and any of this material coming in contact with the skin will leave a serious burn.

When handling asphalt that is being processed, you must wear proper protective apparel. Wear loose, heavy clothing that is in good condition. Clothing should be closed at the neck; sleeves should be rolled down over the tops of gloves. You should wear cuffless trousers that extend well down over the top of safety shoes. Goggles should be worn to prevent eye burns from bubbling or splashing asphalt. In addition, you should wear a safety hard hat.

Frequently, bituminous operations are often planned for roads that must carry traffic while work is in progress. Slow or caution signs or other warning devices should be conspicuously placed at both 100 yards and 20 yards from each entrance of the project. Flagmen, dressed in safety vests or some other safety attire, should aid in traffic control.

Most airfields must remain operational during bituminous operations. The construction schedule, equipment routing, and maximum height of equipment should be discussed with the airfield safety officer. Liaison with air traffic control must be established if trucks and other equipment are to cross runways that are in use.

Machinery and mechanized equipment must be operated only by qualified and authorized personnel. It must not be operated in a manner that will endanger personnel or property. The safe operating speeds or loads must not be exceeded. Equipment, requiring an operator, must not be permitted to run unattended. Mounting or dismounting equipment while it is in motion, or riding on equipment by unauthorized personnel, is prohibited. All equipment, using fuel, must be shut down with the ignition off before and during refueling operations.

When paving equipment is being operated, frequent inspections of running mechanisms and attachments are the operator's responsibility. The operator is also responsible for inspecting such items as the power train, power plant, transmission, tracks, controls, guards, loading or unloading warning devices, and receiving hoppers.

When paving materials are being applied, crew members often become so occupied with their particular job that they are unaware of equipment operating near them. For this reason, at least one crew member should be designated as safety inspector to ensure that reasonable precautions are observed within the assigned working areas. In addition, the safety inspector should periodically hold short (approximately 5 to 15 minutes) safety meetings (called stand-up safety meetings), during which the inspector briefs the crew on the hazardsaand precautions relating to current work.

All hand tools used for paving purposes must be kept in good repair and used only for the purpose for which they were designed. When you are using hand tools, such as rakes, shovels, lutes, and hand tampers, on asphalt paving jobs, these tools should be heated before use and cleaned immediately after use. It is common practice to clean these hand tools by burning off the bitumen, collected during paving operations. Crew members should exercise caution and be forewarned that flames are not always visible. One person should stand by with a fire extinguisher capable of controlling a petroleum fire.

In some areas, oiling roads and cleaning asphalt equipment could cause damage to the environment. This is especially important if there are streams or waterways nearby that could be contaminated. Supervisors and crew members should be advised prior to the start of a job if there are any environmental considerations at the site. Dispose of contaminated rags and waste materials in an environmentally responsible manner.

All personnel should be instructed to report immediately all personal injuries and all property damage regardless of how minor. Reports should be prepared according to the instructions set forth in base or command publications.

APPENDIX I

GLOSSARY

AGGREGATE— Crushed rock or gravel, screened to sizes for use in road surfaces, concrete, or bituminous mixes.

ANGLING DOZER (Angledozer)—A bulldozer with a blade that can be pivoted on a vertical center pin so as to cast its load to either side.

APRON— The front gate of a scraper body.

ASPHALT— A dark brown to black cementitious material in which the predominating constituents are bitumens that occur in nature or are obtained in petroleum processing. Asphalt is a constituent in varying proportions of most crude petroleums.

ASPHALT CEMENT— A fluxed or unfluxed asphalt specially prepared as to quality and consistency for direct use in the manufacture of asphalt pavements.

ASPHALT CONCRETE— High-quality thoroughly controlled hot mixture of asphalt cement and well-graded, high-quality aggregate, thoroughly compacted into a uniform, dense mass.

ASPHALT LEVELING COURSE— A course (asphalt aggregate mixture) of variable thickness used to eliminate irregularities in the contour of an existing surface before a superimposed treatment or construction.

ASPHALT, MEDIUM-CURING (MC)— Cutback asphalt, composed of asphalt cement and a kerosene type of diluent of medium volatility.

ASPHALT, RAPID-CURING (RC)— Cutback asphalt, composed of asphalt cement and naphtha or gasoline type of diluent of high volatility.

ASPHALT, SLOW-CURING (SC)— Cutback asphalt, composed of asphalt cement and oils of low volatility.

AUGER— A rotating drill having a screw thread that carries cuttings away from the face.

AUXILIARY— A helper or standby engine or unit.

AXIS OF ROTATION— The vertical line around which the upper structure rotates.

AXLE, LIVE— A revolving horizontal shaft.

BACKFILL— (1) The material used in refilling a ditch or other excavation. (2) The process of such refilling.

BAIL BLOCK— Block attached to a dragline bucket, through which rope line is reeved. Also referred to as "PADLOCK."

BAIL (BUCKET)— A yoke or spreader, hinged to the sides of a dragline bucket, to which is attached a connecting sheave or chain for hoisting and dragging operations.

BALL JOINT— A connection, consisting of a ball and socket, that will allow a limited hinge movement in any direction.

BANK— Specifically, a mass of soil rising above a digging or trucking level. Generally, any soil that is to be dug from its natural position.

BANK GRAVEL— Gravel found in natural deposits, usually more or less intermixed with fine material, such as sand or clay, and combinations thereof; gravelly clay, gravelly sand, clayey gravel, and sandy gravel indicate the varying proportions of the materials in the mixture.

BASE COURSE— The layer of material immediately beneath the surface or intermediate course. It may be composed of crushed stone, crushed slag, crushed or uncrushed gravel and sand, or combinations of these materials. It also may be bound with asphalt.

BANK YARDS— Yards of soil or rock measured in its original position (before digging).

BEDROCK— Solid rock, as distinguished from boulders.

BENCH— A working level or step in a cut that is made in several layers.

BINDER— (1) Fines which hold gravel together when it is dry. (2) A deposit check that makes a contract valid.

BITUMEN— A class of black or dark-colored (solid, semisolid, or viscous) cementitious substance, natural or manufactured, composed principally of high molecular weight hydrocarbons, or which asphalts, tars, pitches, and asphaltites are typical.

BLASTING MAT– A heavy, flexible fabric of woven wire rope or chain, used to confine blasts.

BLEEDING OR FLUSHING– Is the upward movement of asphalt in an asphalt pavement, resulting in the formation of a film of asphalt on the surface. The most common cause is too much asphalt in one or more of the pavement courses, resulting from too rich a plant mix, an improperly constructed seal coat, too heavy a prime or tack coat, or solvent-carrying asphalt to the surface. Bleeding or flushing usually occurs in hot weather.

BLUE TOPS— Grade stakes with blue tops to indicate finish grade level, usually a 2-inch by 2-inch by 6-inch hub stake.

BM— Bench mark.

BODY— The load carrying part of a truck or scraper.

BOGIE AXLE— Two or more axles, mounted to a frame so as to distribute the load between the axles and permit vertical oscillation of the axles.

BOOM CHORD— A main corner member of a lattice type of boom.

BOOM, CRANE— A long, light boom, usually of lattice construction.

BOOM HOIST— Mechanism to control the elevation of the boom and to support it.

BOOM LACING– Structural truss members at angles to and supporting the boom chords of a lattice type of boom.

BOOM, LATTICE— A long, light boom fabricated of crisscrossed steel or aluminum angles or tubing.

BOOM LENGTH— Boom length is a straight line through the center line of the boom pivot pinto the center line of the boom point load hoist sheave pin, measured along the longitudinal axis of the boom.

BOWL— (1) The bucket or body of a carrying scraper. (2) Sometimes the moldboard or blade of a dozer.

BUCKET— A part of an excavator that digs, lifts, and carries dirt.

BULLDOZER— (1) A tractor equipped with a front pusher blade. (2) In a machine shop, a horizontal press.

CAPILLARY ATTRACTION— The tendency of water to move into fine spaces, as between soil particles, regardless of gravity.

CASING— A pipe lining for a drilled hole.

CAT— (1) A trademark designation for any machine made by the Caterpillar Tractor Company. (2) Widely used to indicate a crawler tractor of any make.

CAT HEAD— A capstan winch.

CATWALK— A pathway, usually of wood or metal, that gives access to parts of large machines.

CENTRIFUGAL FORCE— Outward force exerted by a body moving in a curved line. It is the force that tends to tip a car over in going around a curve.

C-FRAME— An angling dozer lift and push frame.

CHECK VALVE— Any device that will allow fluid or air to pass through it in only one direction.

CHOKER— A chain or cable so fastened that it tightens on its load as it is pulled.

CIRCLE REVERSE— The mechanism that changes the angle of a grader blade.

CLAM— A clamshell bucket.

CLAMSHELL— (1) A shovel bucket with two jaws that clamp together by their own weight when it is lifted by the closing line. (2) A crane equipped with a clamshell bucket.

CLAMSHELL BUCKET— Usually consists of two or more similar scoops hinged together and a head assembly connected to the outer corners by struts. When the head and hinge are pulled toward each other, the scoops are forced together to dig and hold material. Control is by a holding line reeved over a boom point sheave and attached to the head assembly to support the bucket in open position and usually by a closing line also reeved over a boom point sheave, ending in a force amplifying tackle or other means between the head assembly and scoop hinge to close the bucket.

CLAMSHELL BUCKET, HYDRAULIC— Usually consists of two or more scoops hinged to a head assembly housing the hydraulic cylinder or cylinders and the force amplifying linkage to open and close the scoops and to supply the digging force for the scoops. The bucket assembly is suspended from the boom by a rope. Because digging ability is largely dependent upon bucket weight, buckets are supplied in various weight classes which range from light, for easily dug stockpiled materials, to heavy, for excavating hardpan material and the like.

CLAMSHELL EQUIPMENT— Machines with clamshell attachments are used to load material from stockpiles, gondola cars, barges, and the like, or from virgin soil generally out of small-area holes, deep trenches, or from below water. Orange peel buckets, grapples, and similar rope suspended attachments are included in this classification.

CLOSING LINE— The rope reeved from the hoist drum to control closing of a rope-operated clamshell bucket.

COFFERDAM— A set of temporary walls, designed to keep soil and/or water from entering an excavation.

COLLAR— A sliding ring, mounted on a shaft so that it does not revolve with it, used in clutches and transmissions.

COMPACTION— The act of compressing a given volume. Insufficient compaction of the asphalt pavement courses may result in channeling on the pavement surface. Compaction is usually accomplished by rolling.

CONVEYOR BELT— An endless belt of rubber-covered fabric that transports material on its upper surface.

CORRUGATIONS (WASHBOARDING) AND SHOVING— Are types of pavement distortion. Corrugation is a form of plastic movement typified by ripples across the asphalt pavement surface. Shoving is a form of plastic movement, resulting in localized bulging of the pavement surface. These distortions usually occur at points where traffic starts and stops, on hills where vehicles brake on the downgrade, on sharp curves, or where vehicles hit a bump and bounce up and down. They occur in asphalt layers that lack stability. Lack of stability may be caused by a mixture that is too rich in asphalt, has too high a proportion of fine aggregate, has coarse or fine aggregate that is too round or too smooth, or has asphalt cement that is too soft. It may also be due to excessive moisture, contamination due to oil spillage, or lack of aeration when placing mixes using liquid asphalt.

CRACKS— Breaks in the surface of an asphalt pavement.

CRACKS, ALLIGATOR— Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken wire, caused by excessive deflection of the surface over unstable subgrade or lower courses of the pavement.

CRACKS, EDGE JOINT— Are the separation of the joints between the pavement and the shoulder, commonly caused by the alternate wetting and drying beneath the shoulder surface. Other causes are shoulder settlement, mix shrinkage, and trucks straddling the joint.

CRACKS, LANE JOINT— Longitudinal separation along the seam between two paving lanes caused by a weak scam between adjoining spreads in the courses of the pavement.

CRACKS, REFLECTION— Cracks in asphalt overlays that reflect the crack pattern in the pavement structure underneath. They are caused by vertical or horizontal movements in the pavement beneath the overlay, brought on by expansion and contraction with temperature or moisture changes.

CRACKS, SHRINKAGE— Are interconnected cracks forming a series of large blocks, usually with sharp corners or angles. Frequently they are caused by volume change in either the asphalt mix or in the base or subgrade.

CRACKS, SLIPPAGE— Are crescent-shaped cracks that are open in the direction of the thrust of wheels on the pavement surface. They result when there is a lack of good bond between the surface layer and the course beneath.

CRANE— A mobile machine, used for lifting and moving loads without the use of a bucket.

CRANE MATS— A device, used for supporting machines on soft ground, usually of timber construction.

CREEP— (1) Very slow travel of a machine or a part. (2) Unwanted turning of a shaft due to drag in a fluid coupling or other disconnect device.

CRUMBER— A blade that follows the wheel or ladder of a ditching machine to clean and shape the bottom.

CULVERT— A pipe or small bridge for drainage under a road or structure.

CURVE, VERTICAL— A change in gradient of the center line of a road or pipe.

CUTBACK ASPHALTS— Mixture of asphalt cement and a cutting agent. There are three main types.

DATUM— Any level surface taken as a plane of reference from which to measure elevations.

DEADHEADING— Traveling without a load, except when traveling from the dumping area to the loading point.

DENSITY— The ratio of the weight of a substance to its volume.

DIESELING— In a compressor, explosions of mixtures of air and lubricating oil in the compression chambers and/or other parts of the air system.

DOLLY— A unit consisting of a draw tongue, an axle with wheels, and a turntable platform to support a gooseneck trailer.

DOUBLE-CLUTCHING— Disengaging and engaging the clutch twice during a single-gear shift (change of gears) to synchronize gear speeds.

DOWNSTREAM FACE— The dry side of a dam.

DOZER— Abbreviation of bulldozer.

DRAFT— Resistance to movement of a towed load.

DRAGLINE—A crane with a dragline attachment, used to excavate material from below the grade on which the crane is sitting.

DRAWBAR— A fixed or hinged bar, extending to the rear of a tractor and used as a fastening for lines and towed machines or loads.

DRAWBAR HORSEPOWER— A tractor's flywheel horsepower minus friction and slippage losses in the drive mechanism and the tracks or tires.

DRAWBAR PULL— The pull that a tractor can exert on a load attached to the drawbar. Depends on power, weight, and traction.

DRILL COLLAR— Thick-walled drill pipe, used immediately above a rotary bit to provide extra weight.

DRILL, PERCUSSION— A drill that hammers and rotates a steel and bit. Sometimes limited to large blast hole drills of the percussion type.

DRILL PIPE— The sections of a rotary drilling string, connecting the kelly with the bit or collars.

DRIVE SPROCKET— A drive roller with teeth that engage matching recesses or pins (bushings) in the track assembly.

DROP HAMMER— A pile-driving hammer that is lifted by a cable and that obtains striking power by falling freely.

DRUM, SPUDDING— In a churn drill, the winch that controls the drilling line.

EJECTOR— A clean-out device, usually a sliding plate.

EMBANKMENT—A fill whose top is higher than the adjoining surface.

EROSION— Wear caused by moving water or wind.

FACE— (1) The more or less vertical surface of rock exposed by blasting or excavating or the cutting end of a drill hole. (2) An edge of rock used as a starting point in figuring drilling and blasting. (3) The width of a roll crusher.

FACTOR OF SAFETY— The ratio of the ultimate strength of the material to the allowable or working stress.

FAIRLEAD— A device which lines up cable so that it will wind smoothly onto a drum.

FEATHER— To blend the edge of new material into the old surface smoothly.

FIFTH WHEEL— The weight-bearing swivel connection between highway type of tractors and semitrailers.

FILL— An earth or broken rock structure or embankment. Soil or loose rock used to raise a grade. Soil that has no value except bulk.

FLOAT— In reference to a dozer blade, to rest by its own weight or to be held from digging by upward pressure of a load of dirt against its moldboard.

FOOT— In tamping rollers, one of a number of projections from a cylindrical drum.

FOOT-POUND— Unit of work equal to the force in pounds multiplied by the distance in feet through which it acts. When a 1-pound force is exerted through a 1-foot distance, 1 foot-pound of work is done.

FOUR BY FOUR (4 x 4)— A vehicle with four wheels or sets of wheels, all engine-driven.

FREE FALL— Lowering of the hook (with or without a load) without it being coupled to the power train with the lowering speed being controlled by a retarding device, such as a brake.

FRONT-END LOADER— A tractor loader with a bucket that operates entirely at the front end of the tractor.

FROST— Frozen soil.

FROST LINE— The greatest depth to which ground may be expected to freeze.

GANTRY— (1) An overhead structure that supports machines or operating parts. (2) An upward extension of the revolving frame of a crane that holds the boom line sheaves.

GEAR— A toothed wheel, cone, or bar.

GOOSENECK— An arched connection, usually between a tractor and a trailer.

GRADE— (1) Usually the elevation of a real or planned surface. (2) Also means surface slope.

GRADER— A machine with a centrally located blade that can be angled to cast to either side with an independent hoist control on each side.

GRADE STAKE— A stake indicating the amount of cut or fill required to bring the ground to a specified level.

GRAVEL— (1) Rock fragments from 2mm to 64 mm (.08 to 2.5 inches) in diameter. (2) A mixture of such gravel with sand, cobbles, boulders, and not over 15 percent fines.

GRIEF STEM— See “KELLY.”

GRIZZLY— (1) A coarse screen used to remove oversize pieces from earth or blasted rock. (Maybe spelled “grizzlie.”) (2) A gate or closure on a chute.

GROUND PRESSURE— The weight of a machine, divided by the area in square inches of the ground directly supporting it.

GROUSER— Projecting lug(s) attached to or integral with the ma chine track shoes to provide additional tract ion.

GRUBBING— Digging out roots.

HAND LEVEL— A sighting level that does not have a tripod, base, or telescope.

HARDPAN— (1) Hard, tight soil. (2) A hard layer that may form just below plow depth on cultivated land.

HAUL DISTANCE— (1) Is the distance measured along the center line or most direct practical route between the center of the mass of excavation and the center of mass of the fill as finally placed. (2) It is the distance the material is moved.

HOLDING LINE— The cable reeved from a hoist drum for holding a clamshell bucket or grapple suspended during dumping and lowering operations.

HOOK, PINTLE— A towing bracket, having a fixed lower part and a hinged upper one, which, when locked together, makes a round opening.

HOPPER— A storage bin or a funnel that is loaded from the top and discharges through a door or chute in the bottom.

HORSEPOWER— (1) A measurement of power that includes the factors of force and speed. (2) The force required to lift 33,000 pounds 1 foot in 1 minute.

HORSEPOWER, DRAWBAR— Horsepower available to move a tractor and its load after deducting losses in the power train.

HOLDING LINE— The hoist cable for a clamshell bucket.

IDLER— Large end roller of a track assembly at the opposite end from the drive sprocket; the roller is not power-driven.

INJECTOR— In a diesel engine, the unit that sprays fuel into the combustion chamber.

JACK— (1) A mechanical or hydraulic lifting device. (2) A hydraulic ram or cylinder.

JACKKNIFE— A tractor and trailer in such an angle that the tractor cannot move forward.

JAW— (1) In a clutch, one of a pair of toothed rings, the teeth of which face each other. (2) In a crusher, one of a pair of nearly flat faces separated by a wedge-shaped opening.

JIB BOOM— An extension piece, hinged to the upper end of a crane boom.

KELLY— A square or fluted pipe which is turned by a drill rotary table, while it is free to move up and down in the table. Also called a “GRIEF STEM.”

LAGGINGS— Removable and interchangeable drum spool shells for changing the hoist drum diameter to provide variation in rope speeds and line pulls.

LAY— The direction of twist in wires and strands in wire rope.

LAY, REGULAR— A wire rope construction in which the direction of twist of the wires in the strands is opposite to that of the strands in the rope.

LEVEL— To make level or to cause to conform to a specified grade.

LIFT— A layer or course of paving material, applied to a base or a previous layer.

LIP— The cutting edge of a bucket. Applied chiefly to edges including tooth sockets.

LOAD BINDER— A lever that pulls two grab hooks together and holds them by locking over the center.

LOADER, FRONT-END— A tractor loader that both digs and dumps in front.

LOAM— A soft easily worked soil, containing sand, silt, and clay.

LOOSE YARDS— Measurement of soil or rock after it has been loosened by digging or blasting.

LOW BED— A machinery trailer with a low deck.

LUFFING— Operation of changing the boom angle in the vertical plane. See "BOOM HOIST."

LUG DOWN— To slow down an engine by increasing its load beyond its capacity.

MASS DIAGRAM— A plotting of cumulative cuts and fills, used for engineering computation of construction jobs.

MINERAL DUST— The portion of the fine aggregate passing the 0.075-mm (No. 200) sieve.

MINERAL FILLER— A finely divided mineral product, at least 70 percent or which will pass a 0.075-mm (No. 200) sieve. Pulverized limestone is the most commonly manufactured filler, although other stone dust, hydrated lime, portland cement, and certain natural deposits of finely divided mineral matter are also used.

MISFIRE— Failure of all or part of an explosive charge to go off.

MOLDBOARD— A curved surface of a plow, dozer blade, grader blade, or other dirt-moving implement that gives dirt moving over it a rotary, spiral, or twisting movement.

MUCK— Mud rich in humus.

OIL— Any fluid lubricant, but not water.

OPEN-GRADED ASPHALT FRICTION COURSE— A pavement surface course that consists of high-void, asphalt plant mix that permits rapid drainage of rainwater through the course and out the shoulder. The mixture is characterized by a large percentage of one-sized coarse aggregate. This course prevents tire hydroplaning and provides a skid-resistant pavement surface.

OPTIMUM— Best.

OSCILLATION— Independent movement through a limited range, usually on a hinge.

OUTRIGGER— An outward extension of a frame that is supported by a jack or block, used to increase stability.

OVERBURDEN— Soil or rock lying on top of a pay formation.

PAN— A carrying scraper.

PAWL— A tooth or set of teeth, designed to lock against a ratchet.

PENETRATION— The consistency of a bituminous material expressed as a distance in tenths of a millimeter (0.1mm) that a standard needle penetrates vertically a sample of the material under specified conditions of loading, time, and temperature.

PERCENT OF GRADE— Measurement of slope, expressed as the ratio of the change in vertical distance (rise) to the change in horizontal distance (run) multiplied by 100.

PETCOCK— A small drain valve.

PILE CAP— An adapter between the pile-driving unit and the upper end of the pile, used to center the pile under the pile-driving unit and to reduce damage to the upper end of the pile.

PIONEERING— The first working over of rough or overgrown areas.

PIONEER ROAD— A primitive, temporary road built along the route of a job to provide means for moving equipment and men.

POND— A small lake.

PORT— Left side of a ship or boat.

POTHOLE— A small steel-sided hole caused by traffic wear.

POWER EXTRACTOR— A unit hanging from the hoist line or block and attached to the upper end of the pile and containing within itself a member (ram) which is caused to reciprocate either by means of externally supplied air, steam, or hydraulic fluid under pressure, or by internal combustion within the unit. Upward pull from the hoisting machinery supplements the extraction forces.

POWER PLANT— The power plant (or plants) includes the prime power source (which may be an internal combustion engine or electric motor) and the power takeoff.

POWER TAKEOFF— A place in a transmission or engine to which a shaft can be so attached as to drive an outside mechanism. A power takeoff may be direct drive, friction clutch, fluid coupling, hydrodynamic torque converter, hydrostatic, or an electric generator type.

POWER TRAIN— All moving parts connecting an engine with the point or points where work is accomplished.

PRIME MOVER— A tractor or other vehicle used to pull other machines.

PROPELLER SHAFT— Usually a main drive shaft fitted with universal joints.

PSI or psi— Pressure in pounds per square inch.

PUMP, DIAPHRAGM— A pump that moves water by the reciprocating motion of a diaphragm in a chamber having inlet and outlet check valves.

PUSHER— A tractor that pushes a scraper to help it pick up a load.

RAKE BLADE— A dozer blade or attachment made of spaced tines.

RAKE, ROCK— A heavy-duty rake blade.

RANGE POLE— A pole marked in alternate red and white bonds, 1 foot high.

RED TOPS— Grade stakes with red tops to indicate finish subgrade level, usually a 2-inch by 2-inch by 6-inch hub stake.

REFUSAL— The depth beyond which a pile cannot be driven.

RIPRAP— Heavy stones placed at the edge of the water to protect the soil from waves or current.

RIPPER— A towed machine, equipped with teeth, used primarily for loosening hard soil and soft rock.

ROAD OIL— A heavy petroleum oil, usually one of the slow-curing (sc) grades.

ROCK— The hard, firm, and stable parts of earth's crust.

ROTARY TILLER— A machine that loosens and mixes soil and vegetation by means of a high-speed rotor equipped with tines.

RPM or rpm— Revolutions per minute.

RUBBLE DRAINS— French drains.

RULE OF THUMB— A statement or formula that is not exactly correct but is accurate enough for use in rough figuring.

SAND— A loose soil, composed of particles between 1/16 mm and 2 mm in diameter.

SCRAPER (Carrying scraper) (Pan)— A digging, hauling, and grading machine, having a cutting edge, a carrying bowl, a movable front wall (apron), and a dumping or ejecting mechanism.

SCREEN— (1) A mesh or bar surface, used for separating pieces or particles of different sizes. (2) A filter.

SEIZE— To bind wire rope with soft wire to prevent it from raveling when it is cut.

SEMITRAILER— A towed vehicle whose front rests on the towing unit.

SHEEPSFOOT— A tamping roller with feet expanded at their outer tips.

SHOE— (1) A ground plate, forming a link of a track or bolted to a track link. (2) A support for a bulldozer blade or other digging edge to prevent cutting down. (3) A clean-up device following the buckets of a ditching machine.

SIDECASTING— Piling spoil alongside the excavation from which it is taken.

SNATCH BLOCK— A pulley in a case that can be easily fastened to lines or objects by means of a hook, ring, or shackle.

SPILLWAY— An overflow channel for a pond or a terrace channel.

SPROCKET— A gear that meshes with a chain or a crawler track.

STOCKPILE— Material dug and piled for future use.

STONE— Rock.

SUPERCHARGER— A blower that increases the intake pressure of an engine.

SURGE BIN— A compartment for temporary storage.

SWELL (Growth)— Increase of bulk in soil or rock when it is dug or blasted.

SWING LOCK— A swing lock is a mechanical engagement device, not dependent on friction, to hold the upper structure in one or more fixed positions with respect to the undercarriage. When provided, it must be constructed to prevent unintentional engagement or disengagement.

SWING BRAKE (Dynamic)— A dynamic swing brake is a device to stop, hold, or retard the rotating motion of the upper structure with respect to the undercarriage.

SWITCHBACK— A hair-pin curve.

TAG LINE— A line from a crane boom to a clamshell bucket that holds the bucket from spinning out of position.

TAMP— Pound or press soil to compact it.

TERRACE— A ridge, a ridge and hollow, or a flat bench built along a ground contour.

TERRAIN— Ground surface.

TOE— The projection of the bottom of a face beyond the top.

TOOTH ADAPTER— Main part of bucket or dipper to which a removable tooth is fastened.

TOPOGRAPHIC MAP— A map, indicating surface elevation and slope.

TOPSOIL— The topmost layer of soil, usually refers to soil containing humus that is capable of supporting good plant growth.

TORQUE— The twisting force exerted by or on a shaft (without reference to the speed of the shaft).

TRACK— A crawler track.

TRACK CARRIER ROLLERS— Rolling elements in/on a track frame that support and guide the upper track shoes or chain.

TRACK SHOES— The members of the track assembly that distribute the load to the supporting surface.

TRACTION— The total amount of driving push of a vehicle on a given surface.

TRENCH— A ditch.

TRUNNION (Walking beam or bar)— (1) An oscillating bar that allows changes in angle between a unit fastened to its center and another attached to both ends. (2) A heavy horizontal hinge.

UNDERCARRIAGE— The undercarriage is an assembly that supports the upper structure of the crane. It consists of an undercarriage frame, a swing bearing, or hook and load rollers, travel mechanism, and steering mechanism. The undercarriage may be either a crawler or wheeled type.

VISCOSITY— The resistance of a fluid to flow. A liquid with a high viscosity rating will resist flow more readily than will a liquid with a low viscosity. The Society of Automotive Engineers (S.A.E.) has developed a series of viscosity numbers for indicating viscosities of lubricating oils.

VOIDS— Empty spaces in a compacted mix, surrounded by asphalt-coated particles.

VOLTS— The electromotive force that will cause a current of 1 ampere to flow through a resistance of 1 ohm.

WATERLOGGED— Saturated with water. If conditions are too wet, you will be unable to work construction equipment.

WATERSHED— Area that drains into or pasta point.

WATER TABLE— The surface of underground, gravity-controlled water.

WHEEL AND AXLE ARRANGEMENT— The wheeled undercarriages.

WINCH— A drum that can be rotated so as to exert a strong pull while winding in a line.

WINDROW— A ridge of loose dirt.

WING WALL— A wall that guides a stream into a bridge opening or culvert barrel.

WORKING CYCLE— A complete set of operations. In an excavator, it usually includes loading, moving, dumping, and returning to the loading point.

APPENDIX II

INTERNATIONAL SIGNALS AND ROAD SIGNS

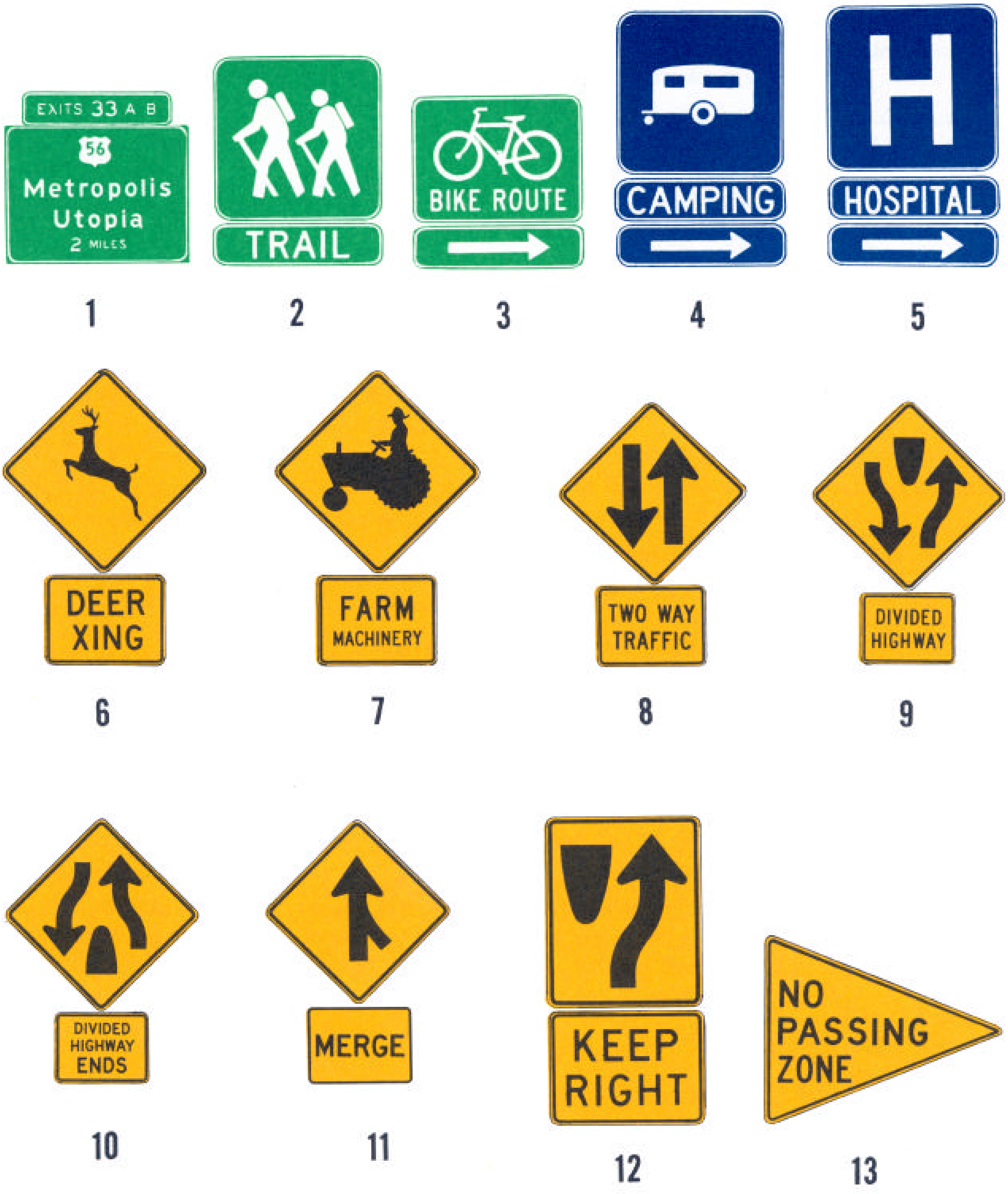
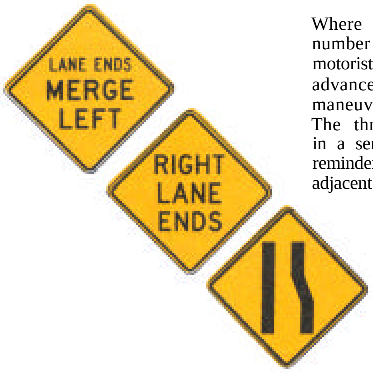
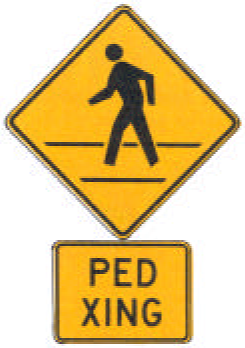

EXITS 33 A B
56
Metropolis
Utopia
2 MILES
1
TRAIL
2
BIKE ROUTE
3
CAMPING
4
H
HOSPITAL
5
DEER
XING
6
FARM
MACHINERY
7
TWO WAY
TRAFFIC
8
DIVIDED
HIGHWAY
9
DIVIDED
HIGHWAY
ENDS
10
MERGE
11
KEEP
RIGHT
12
NO
PASSING
ZONE
13

Figure AII-1.—New traffic signs and markings.

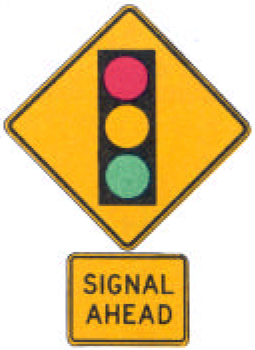

LANE ENDS
MERGE
LEFT
RIGHT
LANE
ENDS

Where sudden changes in the number of highway lanes occur, motorists need to be alerted in advance so that the proper maneuvers can be completed. The three signs above appear in a series to serve as a repeating reminder to merge info the adjacent lane.

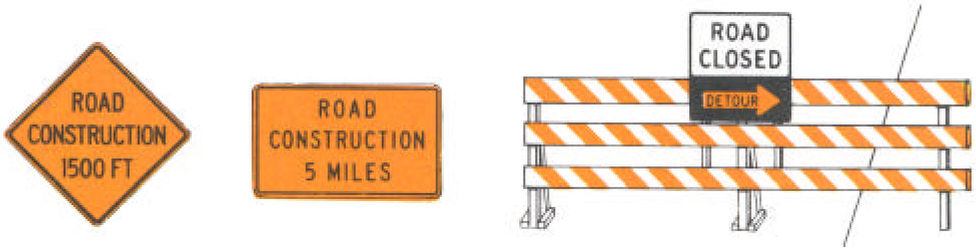
14



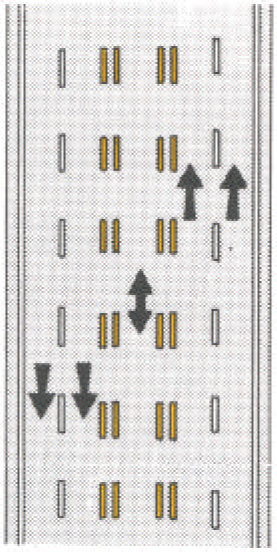
15


SIGNAL
AHEAD

16

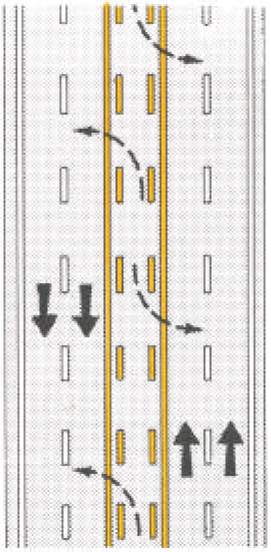

ROAD
CONSTRUCTION
1500 FT
ROAD
CONSTRUCTION
5 MILES
ROAD
CLOSED
DETOUR

17



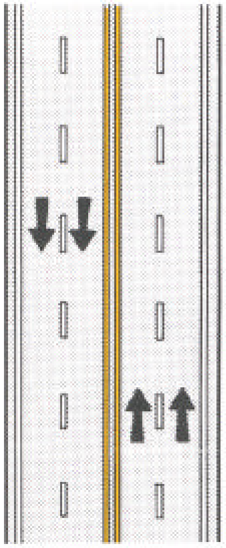
Multi-lane. two way roadway, with center lane direction reversible during specified periods Such markings are supplemented with **signs** or signals.

18



Multi-lane, two way roadway, with two way left turn lane reserved exclusively for left turning vehicles in either direction.

19

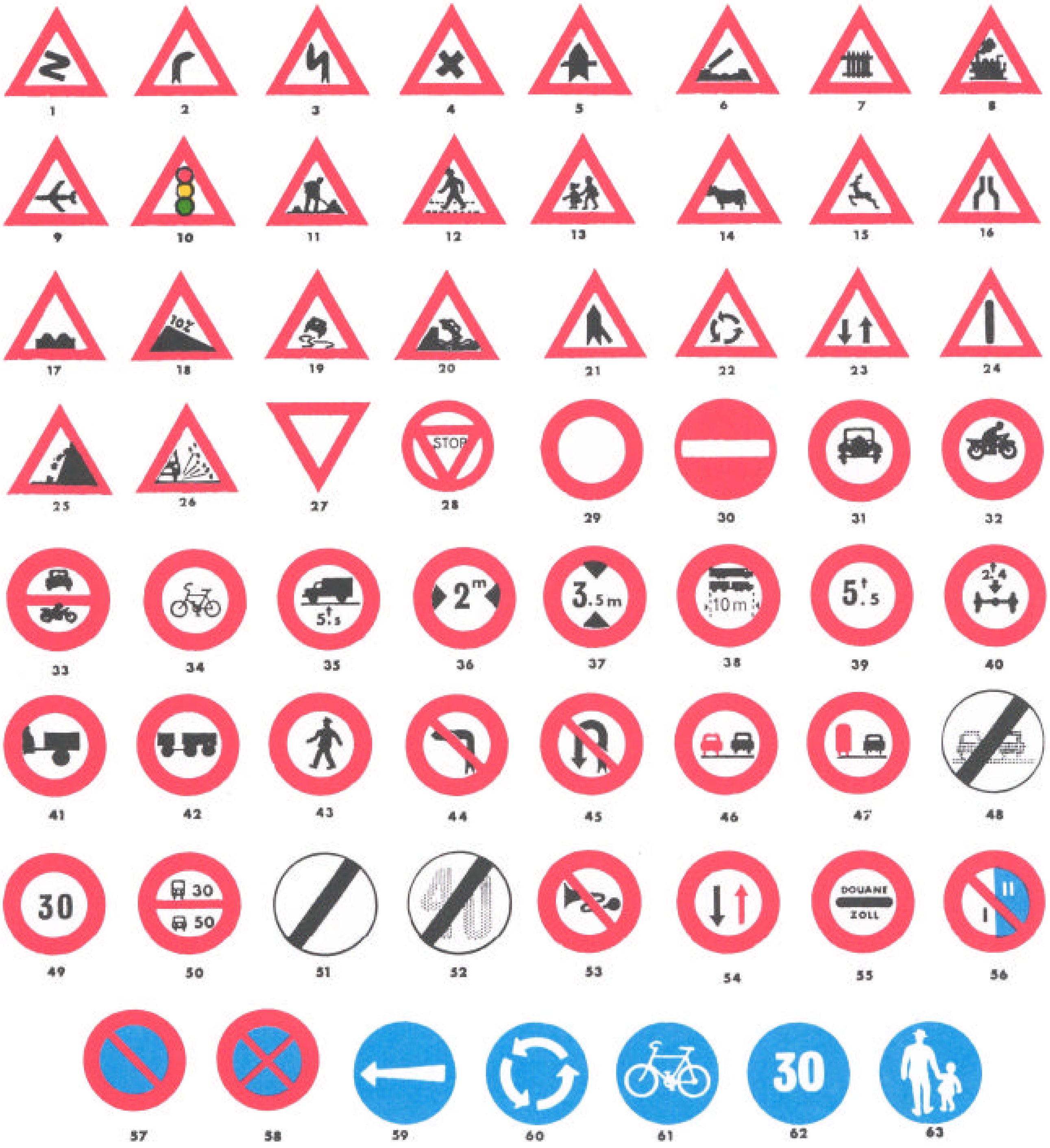


Multi-lane. two way roadway, crossing centerline permitted only as part of left turn maneuver.

20

C115.505.2

Figure AII-1.—New traffic signs and markings—Continued.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
10%
18
19
20
21
22
23
24
25
26
27
STOP
28
29
30
31
32
33
34
5t5
35
2m
36
3.5m
37
10m
38
5t5
39
2t4
40
41
42
43
44
45
46
47
48
30
49
30
50
50
51
40
52
53
54
DOUANE
ZOLL
55
I
II
56
57
58
59
60
61
30
62
63

C29.53

Figure AII-2.—International road signs.

1 Dangerous bend
2 Right bend
3 Double bend
4 Intersection
5 Intersection with a non-priority road
6 Opening bridge
7 Level-crossing with gates
8 Level-crossing without gates
9 Low flying aircraft
10 Traffic signals ahead
11 Road works
12 Pedestrian crossing
13 Children
14 Beware of animals
15 Animals crossing
16 Road narrows
17 Uneven road
18 Dangerous hill
19 Slippery road
20 Quay or river bank
21 Merging traffic
22 Roundabout ahead
23 Two-way traffic
24 Danger
25 Danger from falling rocks
26 Loose chippings
27 Priority road ahead
28 Stop at intersection
29 Closed to all vehicles
30 No entry for all vehicles
31 No entry for all motor vehicles except motorcycles without sidecars
32 No entry for motorcycles without sidecars
33 No entry for all motor vehicles
34 No entry for pedal cyclists
35 No entry for goods vehicles exceeding...tons laden weight
36 No entry for vehicles having overall width exceeding... metres
37 No entry for vehicles having overall height exceeding . . .metres
38 No entry for vehicles having overall length exceeding . . .metres
39 No entry for vehicles exceeding...tons laden weight
40 No entry for vehicles having an axle weight exceeding.. tons
41 Closed to all motor vehicles drawing a trailer other than a semi-trailer or a single-wheel trailer
42 Closed to lorries drawing a trailer
43 Closed to pedestrians
44 No left (or right) turns
45 No U turns
46 Overtaking prohibited
47 Overtaking by lorries prohibited
48 End of prohibition
49 Speed limit
50 Speed limits for light and heavy motor vehicles
51 End of speed limit
52 End of speed limit
53 Use of horn prohibited
54 Priority to be given to vehicles coming in the opposite direction
55 Stop: customs
56 No parking - on left on uneven dates; on right on even dates
57 No parking
58 Stopping prohibited
59 Direction to be followed
60 Roundabout
61 Compulsory cycle track
62 Compulsory minimum speed
63 Compulsory way for pedestrians

Figure AII-2A.—Nomenclature for figure AII-2.

APPENDIX III

THE METRIC SYSTEM

The metric system was developed by French scientists in 1790 and was specifically designed to be an easily used system of weights and measures to benefit science, industry, and commerce. Soon after development, scientists the world over adopted it for their work.

Early in the nineteenth century many European countries adopted the new system for engineering and commerce. It was possible for these countries to trade manufactured goods with one another and not be concerned with having to buy special wrenches and tools to repair the machinery received in trade. Countries could buy and sell machine tools and precision instruments without having to modify or alter them.

Today, with the exception of the United States and a few small countries, the entire world is using predominantly the metric system or is committed to its use. It becomes a matter of time until the United States adopts the International System of Units (SI), which is the formal name for the metric system. Exactly when the United States will adopt this system or how long it will take to change from the use of non-SI units to SI units is unknown. Meanwhile, the use of SI units is sure to spread and is expected to become universal soon. Much of the equipment in the United States Navy is already measured in SI units. Certain of its weapons are sized in “metric,” such as 20 millimeters and 40 millimeters. Existing maps and charts may show distances in meters (instead of yards) and kilometers (instead of miles).

Some SI units are base units; that is, metric standards defined and adopted by international treaty. Other SI units are derived from the base units and are either expressed in terms of the base unit or are specially named. The base unit for measuring distance, the meter, is defined as one ten-millionth of the distance from the Equator to the North Pole. The metric standard for weight, the gram, is defined as the weight of one cubic centimeter of pure water. Other SI standards include the second (time) and the degree Celsius (temperature), which was formerly called centigrade. The square meter (area), cubic meter (volume), and meter per second (speed) are derived units expressed in terms of the base unit. Derived units having special names include the hertz (frequency), watt (power), and farad (capacitance), volt (electromotive force), and ohm (electric resistance).

The metric system is a base-10 (decimal) number system. It is convenient and easy to use because one unit of measure is converted to smaller and larger units of measure by dividing and multiplying by powers often or by shifting the decimal point. For example, 12.3 millimeters convert to 1.23 centimeters. Calculations, such as dividing by 16 (to convert ounces to pounds) and multiplying by 12 (to convert feet to inches), are eliminated.

The result of multiplying a base unit by a power of ten is referred to as a multiple; the result of dividing by a power of ten, a submultiple. Names of multiples and submultiple of the base unit are formed by adding prefixes to the name of the base unit. The already mentioned millimeter, centimeter, and kilometer are examples.

It is rather simple to relate SI units to non-SI units. Compared to the yard, the meter is a little longer (about 0.6 mile). The basic unit of volume, the liter, is a little larger than a quart (about 1.06 qt). The weight of a liter of pure water is 1 kilogram, which is a little more than 2 pounds (about 2.2 lb). The SI unit for measuring power, the kilowatt, is somewhat bigger than one horsepower (about 1.3 hp).

In working non-SI units and SI units, it helps to have a table of common equivalent weights and measures, such as the one that follows. This table also gives the factor you multiply by in order to convert a non-SI unit to an SI unit, or vice versa. For example:

3 inches = 3 x 25.4 or 76.2 mm (exact)

5 kilometers = 5 x 0.6 or 3 miles (approximate)

For a more detailed study of the metric system, refer to the correspondence course "The Metric System," NAVEDTRA 475-01-00-79. This course is available to you through your ESO office.

ENGLISH AND METRIC SYSTEM UNITS OF MEASUREMENT
COMMON EQUIVALENTS AND CONVERSIONS

Approximate Common Equivalents		Conversions Accurate to Parts Per Million (units stated in abbreviated form) Number X Factor	
1 inch	= 25 millimeters	in X 25.4*	= mm
1 foot	= 0.3 meter	ft X 0.3048*	= m
1 yard	= 0.9 meter	yd X 0.9144*	= m
1 mile†	= 1.6 kilometers	mi X 1.60934	= km
1 square inch	= 6.5 square centimeters	in^2 X 6.4516*	= cm^2
1 square foot	= 0.09 square meter	ft^2 X 0.0929030	= m^2
1 square yard	= 0.8 square meter	yd^2 X 0.836127	= m^2
1 acre	= 0.4 hectare	acres X 0.404686	= ha
1 cubic inch	= 16 cubic centimeters	in^3 X 16.3871	= cm^3
1 cubic foot	= 0.03 cubic meter	ft^3 X 0.0283168	= m^3
1 cubic yard	= 0.8 cubic meter	yd^3 X 0.764555	= m^3
1 quart (1q.)	= 1 liter	qt (1q.) X 0.946353	= *l*
1 gallon	= 0.004 cubic meter	gal X 0.00378541	= m^3
1 ounce (avdp)	= 28 grams	oz (avdp) X 28.3495	= g
1 pound (avdp)	= 0.45 kilogram	lb (avdp) X 0.453592	= kg
1 horsepower	= 0.75 kilowatt	hp X 0.745700	= kW
1 pound per square inch	= 0.07 kilogram per square centimeter	psi X 0.0703224	= kg/cm^2
1 millimeter	= 0.04 inch	mm X 0.0393701	= in
1 meter	= 3.3 feet	m X 3.28084	= ft
1 meter	= 1.1 yards	m X 1.09361	= yd
1 kilometer	= 0.6 mile	km X 0.621371	= mi
1 square centimeter	= 0.16 square inch	cm^2 X 0.155000	= in^2
1 square meter	= 11 square feet	m^2 X 10.7639	= ft^2
1 square meter	= 1.2 square yards	m^2 X 1.19599	= yd^2
1 hectare	= 2.5 acres	ha X 2.47105	= acres
1 cubic centimeter	= 0.06 cubic inch	cm^3 X 0.0610237	= in^3
1 cubic meter	= 35 cubic feet	m^3 X 35.3147	= ft^3
1 cubic meter	= 1.3 cubic yards	m^3 X 1.30795	= yd^3
1 liter	= 1 quart (1q.)	*l* X 1.05669	= qt (1q.)
1 cubic meter	= 250 gallons	m^3 X 264.172	= gal
1 gram	= 0.035 ounces (avdp)	g X 0.0352740	= oz (avdp)
1 kilogram	= 2.2 pounds (avdp)	kg X 2.20462	= lb (avdp)
1 kilowatt	= 1.3 horsepower	kW X 1.34102	= hp
1 kilogram per square centimeter	= 14.2 pounds per square inch	kg/cm^2 X 14.223226	= psi

†nautical mile = 1.852 kilometers

* exact

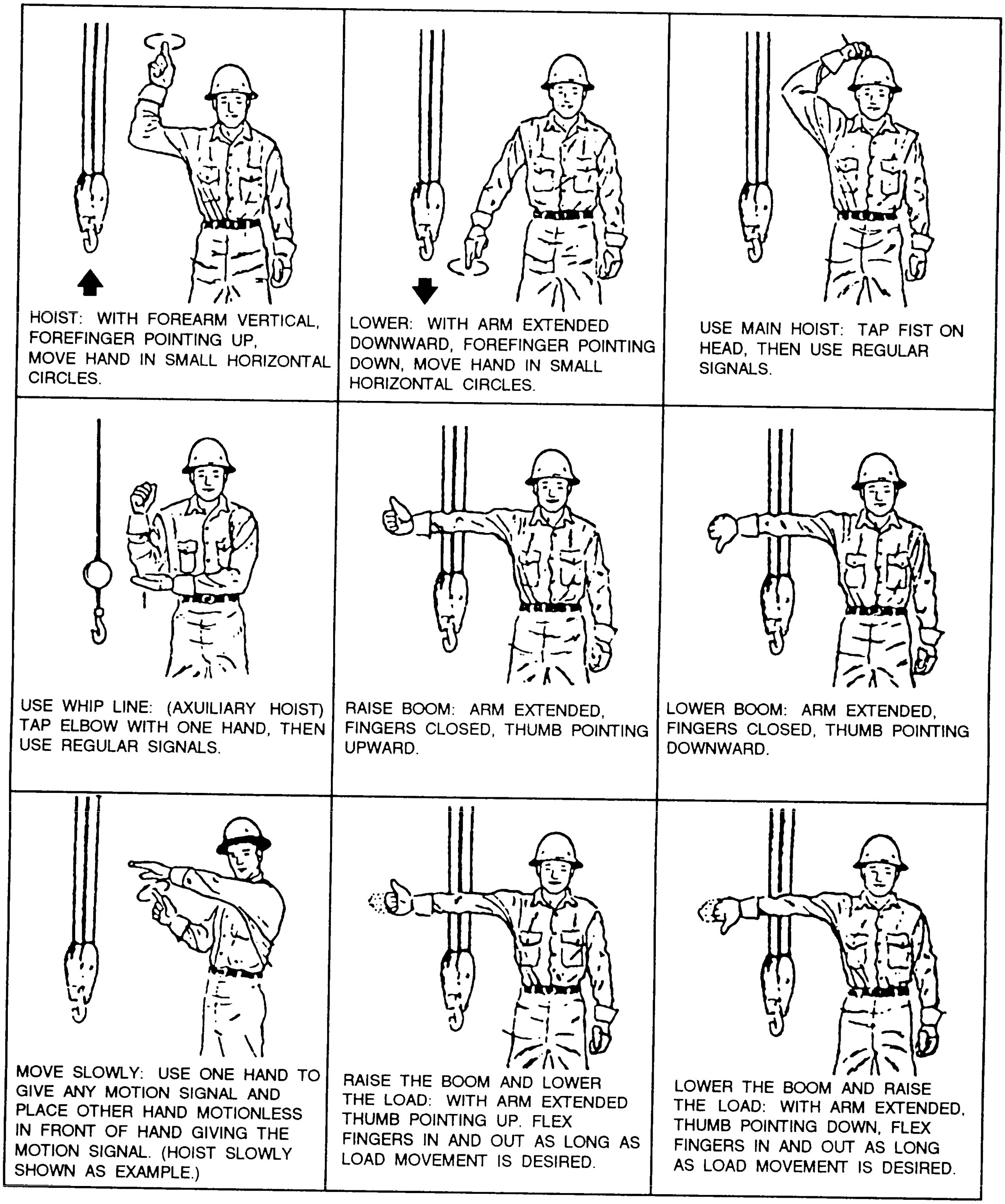
CONVERSION TABLES

MULTIPLY	BY	TO OBTAIN
Acres	43,560	square feet
Acres	4047	square meters
Acres	1.562×10^{-3}	square miles
Acres	5645.38	square yards
Acres	4840	square yards
Board-feet	0.2530	cubic inches
British thermal units	144 sq. in. × 1 in.	kilogram-calories
British thermal units	777.5	foot-pounds
British thermal units	3.927×10^{-4}	horsepower-hours
British thermal units	1054	joules
British thermal units	107.5	kilogram-meters
British thermal units	2.928×10^{-4}	kilowatt-hours
Btu per min	12.96	foot-pounds per sec
Btu per min	0.2356	horsepower
Btu per min	0.01757	kilowatts
Btu per min	17.57	watts
Btu per sq ft per min	0.1220	watts per square inch
Centiliters	0.01	liters
Centimeters	0.3937	inches
Centimeters	0.01	meters
Centimeters	393.7	mils
Centimeters	10	millimeters
Cubic centimeters	3.531×10^{-3}	cubic feet
Cubic centimeters	6.102×10^{-2}	cubic inches
Cubic centimeters	10^{-6}	Cubic meters
Cubic centimeters	1.306×10^{-6}	cubic yards
Cubic centimeters	2.642×10^{-4}	gallons
Cubic centimeters	10^{-2}	liters
Cubic centimeters	2.113×10^{-3}	pints (liq)
Cubic centimeters	1.057×10^{-3}	quarts (liq)
Cubic feet	2.832×10^{6}	cubic cms
Cubic feet	1728	cubic inches
Cubic feet	0.02832	cubic meters
Cubic feet	0.03704	cubic yards
Cubic feet	7.481	gallons
Cubic feet	28.32	liters
Cubic feet	59.84	pints (liq)
Cubic feet	29.92	quarts (liq)
Cubic feet per minute	472.0	cubic cms per sec
Cubic feet per minute	0.1247	gallons per sec
Cubic feet per minute	0.4720	liters per second
Cubic feet per minute	82.4	lbs of water per min
Cubic inches	16.39	cubic centimeters
Cubic inches	5.787×10^{-4}	cubic feet
Cubic inches	1.639×10^{-5}	cubic meters
Cubic inches	2.143×10^{-5}	cubic yards
Cubic inches	4.329×10^{-2}	gallons
Cubic inches	1.639×10^{-2}	liters
Cubic inches	0.03463	pints (liq)
Cubic inches	0.01732	quarts (liq)
Cubic meters	10^{4}	cubic centimeters
Cubic meters	35.31	cubic feet
Cubic meters	81.023	cubic inches
Cubic meters	1.303	cubic yards
Cubic meters	264.2	gallons
Cubic meters	10^{2}	liters
Cubic meters	2113	pints (liq)
Cubic meters	1057	quarts (liq)
Cubic yards	7.646×10^{5}	cubic centimeters
Cubic yards	27	cubic feet
Cubic yards	46.656	cubic inches
Cubic yards	0.7646	cubic meters
Cubic yards	202.0	gallons
Cubic yards	764.6	liters
Cubic yards	1616	pints (liq)
Cubic yards	807.9	quarts (liq)
Cubic yards per minute	0.45	cubic feet per second
Cubic yards per minute	3.367	gallons per second
Cubic yards per minute	12.74	liters per second
Days	24	hours
Days	1440	minutes
Days	86,400	seconds
Fathoms	6	feet
Feet	30.48	centimeters
Feet	12	inches
Feet	0.3048	meters
Feet	.36	yards
Feet	1/3	yards
Feet of water	0.02950	atmosphere
Feet of water	0.8826	inches of mercury
Feet of water	304.8	kgs per square meter
Feet of water	62.43	pounds per sq ft
Feet of water	0.4335	pounds per sq inch
Foot-pounds	1.286×10^{-3}	British thermal units
Foot-pounds	1.356×10^{7}	ergs
Foot-pounds	5.050×10^{-7}	horsepower-hours
Foot-pounds	1.356	joules
Foot-pounds	3.241×10^{-4}	kilogram-calories
Foot-pounds	0.1383	kilogram-meters

MULTIPLY	BY	TO OBTAIN	MULTIPLY	BY	TO OBTAIN
Foot-pounds	3.766×10^{-7}	kilowatt-hours	Kilometers	0.6214	miles
Gallons	3785	cubic centimeters	Kilometers	1093.6	yards
Gallons	0.1337	cubic feet	Kilowatts	56.92	Btu per min
Gallons	231	cubic inches	Kilowatts	4.425×10^{2}	foot-pounds per min
Gallons	3.785×10^{-3}	cubic meters	Kilowatts	737.6	foot-pounds per sec
Gallons	4.951×10^{-3}	cubic yards	Kilowatts	1.341	horsepower
Gallons	3.785	liters	Kilowatts	14.34	kg.-calories per min
Gallons	8	pints (liq)	Kilowatts	10^{3}	watts
Gallons	4	quarts (liq)	Liters	10^{2}	cubic centimeters
Horse-power	42.44	Btu per min	Liters	0.03531	cubic feet
Horse-power	33,000	foot-pounds per min	Liters	61.02	cubic inches
Horse-power	550	foot-pounds per sec	Liters	10^{3}	cubic meters
Horse-power	1.014	horsepower (metric)	Liters	1.308×10^{-2}	cubic yards
Horse-power	10.70	kg.-calories per min	Liters	0.2642	gallons
Horse-power	0.7457	kilowatts	Liters	2.113	pints (liq)
Horse-power	745.7	watts	Liters	1.057	quarts (liq)
Horse-power (boiler)	33.520	Btu per hour	Meters	100	centimeters
Horse-power (boiler)	9.804	kilowatts	Meters	3.2808	feet
Horse-power-hours	2547	British thermal units	Meters	39.37	inches
Horse-power-hours	1.98×10^{4}	foot-pounds	Meters	10^{-3}	kilometers
Horse-power-hours	2.684×10^{4}	joules	Meters	10^{3}	millimeters
Horse-power-hours	641.7	kilogram-calories	Meters	1.0936	yards
Horse-power-hours	2.737×10^{4}	kilogram-meters	Meter-kilograms	9.807×10^{7}	centimeter-dynes
Horse-power-hours	0.7457	kilowatt-hours	Miles	1.609×10^{3}	centimeters
Hours	60	minutes	Miles	5280	feet
Hours	3600	seconds	Miles	1.6093	kilometers
Inches	2.540	centimeters	Miles	1760	yards
Inches	10^{4}	mils	Miles	1900.8	yards
Inches	.03	yards	Ounces	8	drams
Inches of mercury	0.03342	atmospheres	Ounces	437.5	grains
Inches of mercury	1.133	feet of water	Ounces	28.35	grams
Inches of mercury	345.3	kgs per square meter	Ounces	0.0625	pounds
Inches of mercury	70.73	pounds per square ft	Ounces (fluid)	1.805	cubic inches
Inches of mercury	0.4912	pounds per square in	Ounces (fluid)	0.02957	liters
Inches of water	0.002458	atmospheres	Ounces (troy)	480	grains (troy)
Inches of water	0.07355	inches of mercury	Ounces (troy)	31.10	grams
Inches of water	25.40	kgs per square meter	Ounces (troy)	20	pennyweights troy
Inches of water	0.5781	ounces per square in	Ounces (troy)	0.08333	pounds (troy)
Inches of water	5.204	pounds per square ft	Ounces per sq inch	0.0625	pounds per sq inch
Inches of water	0.03613	pounds per square in	Pounds	7000	grains
Joules	9.486×10^{-4}	British thermal units	Pounds	453.6	grams
Kilograms	10^{2}	grams	Pounds	16	ounces
Kilograms	70.93	poundals	Pounds	32.17	poundals
Kilograms	2.2046	pounds	Pounds (troy)	0.8229	pounds (av)
Kilograms	1.102×10^{-2}	tons (short)	Pounds of water	0.01602	cubic feet
Kilometers	3281	feet	Pounds of water	27.68	cubic inches
Kilometers	10^{7}	meters	Pounds of water	0.1198	gallons

APPENDIX IV

HAND SIGNALS



HOIST: WITH FOREARM VERTICAL, FOREFINGER POINTING UP, MOVE HAND IN SMALL HORIZONTAL CIRCLES.

LOWER: WITH ARM EXTENDED DOWNWARD, FOREFINGER POINTING DOWN, MOVE HAND IN SMALL HORIZONTAL CIRCLES.

USE MAIN HOIST: TAP FIST ON HEAD, THEN USE REGULAR SIGNALS.

USE WHIP LINE: (AXUILIARY HOIST) TAP ELBOW WITH ONE HAND, THEN USE REGULAR SIGNALS.

RAISE BOOM: ARM EXTENDED, FINGERS CLOSED, THUMB POINTING UPWARD.

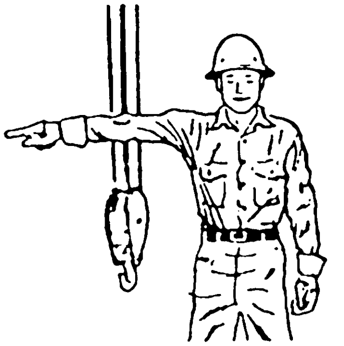
LOWER BOOM: ARM EXTENDED, FINGERS CLOSED, THUMB POINTING DOWNWARD.

MOVE SLOWLY: USE ONE HAND TO GIVE ANY MOTION SIGNAL AND PLACE OTHER HAND MOTIONLESS IN FRONT OF HAND GIVING THE MOTION SIGNAL. (HOIST SLOWLY SHOWN AS EXAMPLE.)

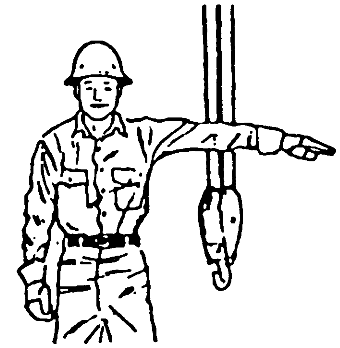
RAISE THE BOOM AND LOWER THE LOAD: WITH ARM EXTENDED THUMB POINTING UP. FLEX FINGERS IN AND OUT AS LONG AS LOAD MOVEMENT IS DESIRED.

LOWER THE BOOM AND RAISE THE LOAD: WITH ARM EXTENDED, THUMB POINTING DOWN, FLEX FINGERS IN AND OUT AS LONG AS LOAD MOVEMENT IS DESIRED.

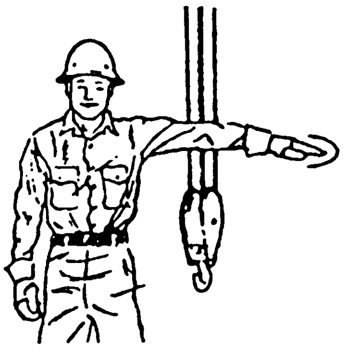
AIV-1.—Standard Operator's Hand Signals.



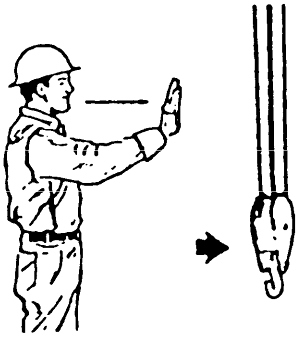
SWING: ARM EXTENDED POINT WITH FINGER IN DIRECTION OF SWING OF BOOM.



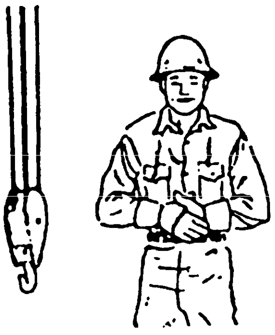
STOP: ARM EXTENDED, PALM DOWN, HOLD POSITION RIGIDLY.



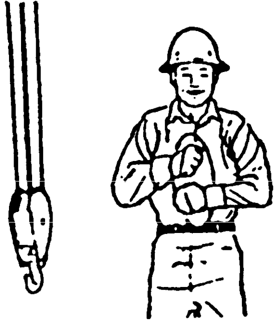
EMERGENCY STOP: ARM EXTENDED, PALM DOWN, MOVE HAND RAPIDLY RIGHT AND LEFT.



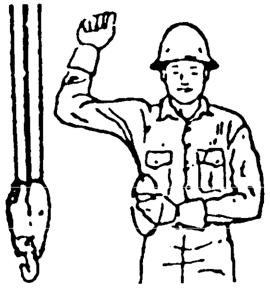
TRAVEL: ARM EXTENDED FORWARD, HAND OPEN AND SLIGHTLY RAISED, MAKE PUSHING MOTION IN DIRECTION OF TRAVEL.



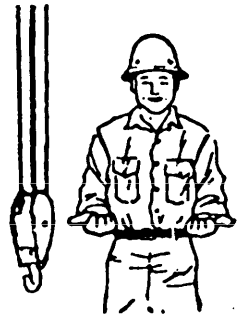
DOG EVERYTHING: CLASP HANDS IN FRONT OF BODY.



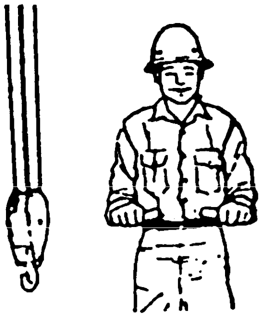
TRAVEL: (BOTH TRACKS) USE BOTH FISTS, IN FRONT OF BODY, MAKING A CIRCULAR MOTION, ABOVE EACH OTHER, INDICATING DIRECTION OF TRAVEL, FORWARD OR BACKWARD (FOR CRAWLER CRANES ONLY.)



TRAVEL: (ONE TRACK) LOCK THE TRACK ON SIDE INDICATED BY RAISED FIST, TRAVEL OPPOSITE TRACK IN DIRECTION INDICATED BY CIRCULAR MOTION OF OTHER FIST, ROTATED VERTICALLY IN FRONT OF BODY (FOR CRAWLER CRANES ONLY.)

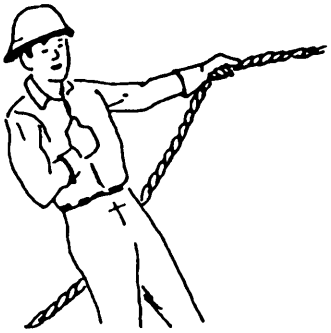


EXTEND BOOM: (TELESCOPING BOOM) BOTH FISTS IN FRONT OF BODY WITH THUMBS POINTING OUTWARD.

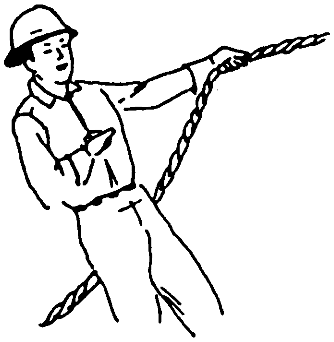


RETRACT BOOM: (TELESCOPING BOOM) BOTH FISTS IN FRONT OF BODY WITH THUMBS POINTING TOWARD EACH OTHER.

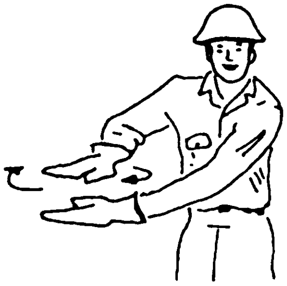
AIV-1.—Standard Operator's Hand Signal—Continued.



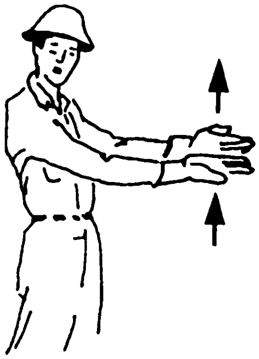
EXTEND BOOM: (TELESCOPING BOOM) ONE HAND SIGNAL. ONE FIST IN FRONT OF CHEST WITH THUMB TAPPING CHEST.



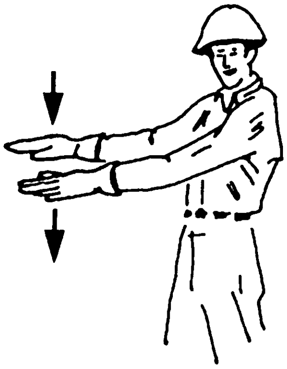
RETRACT BOOM: (TELESCOPING BOOM) ONE HAND SIGNAL. ONE FIST IN FRONT OF CHEST, THUMB POINTING OUTWARD AND HEEL OF FIST TAPPING CHEST.



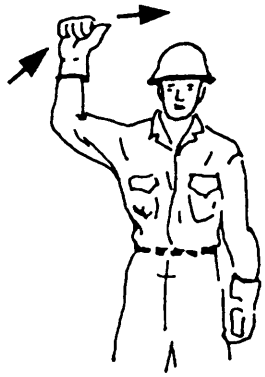
WHEN CUT, FILL OR HAUL ROAD IS TO BE DRAGGED OR BLADED, POINT TO THE AREA, THEN RUB PALMS OF HANDS TOGETHER INDICATING A SMOOTHING MOTION. APPLIES TO SCRAPERS, MOTOR GRADERS AND BULLDOZERS.



RAISE A LITTLE



LOWER A LITTLE



DUMP LOAD NOW: (START DUMPING AND SPREADING LOAD TO PROPER DEPTH IF GIVEN.)

AIV-1.—Standard Operator's Hand Signal—Continued.

APPENDIX V

REFERENCES USED TO DEVELOP THIS TRAMAN

CHAPTER 1

Construction Mechanic 1, NAVEDTRA 10645-F1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1989.

Construction Mechanic 3 & 2, NAVEDTRA 10644-G1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1988.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J/1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1987.

Fundamental of Service, Electrical Systems, 5th ed., Deere & Company, Moline, IL, 1984.

Fundamental of Service, Engine, 5th ed., Deere & Company, Moline, IL, 1980.

General Purpose Vehicle Mechanic, CDC 47252, Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1985.

Principles of Automotive Vehicles, TM 9-8000, Headquarters, Department of the Army, Washington, DC, 1988.

Principles of Gasoline and Diesel Fuel Systems, Subcourse OD1620, U.S. Army Correspondence Course Program, USA Ordnance Center and School, Aberdeen Proving Ground, MD, 1991.

CHAPTER 2

Construction Mechanic 1, NAVEDTRA 10645-F1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1989.

Construction Mechanic 3 & 2, NAVEDTRA 10644-G1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1988.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1987.

Fundamentals of Service, Power Trains, Deere & Company, Moline, IL, 1984.

Principles of Automotive Vehicles, TM 9-8000, Headquarters, Department of the Army, Washington, DC, 1988.

CHAPTER 3

Construction Mechanic 1, NAVEDTRA 10645-F1, Naval Education and Training Program Management Support Activity, Pensacola FL, 1989.

Construction Mechanic 3 & 2, NAVEDTRA 10644-G1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1988.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1987.

Fundamentals of Service, Tires and Tracks, 5th ed., Deere & Company, Moline, IL, 1986.

Manual for Truck and Bus Drivers, Commercial Drivers License, Florida Department of Highway Safety and Motor Vehicles, Tallahassee, FL, 1989.

Nichols, Herbert L., Jr., *Moving the Earth,* 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Principles of Automotive Vehicles, TM 9-8000, Headquarters, Department of the Army, Washington, DC, 1988.

Tire Repair and Maintenance, U.S. Army Engineer School, Fort Belvoir, VA, 1969.

CHAPTER 4

Construction Mechanic, Advanced, NAVEDTRA 12528, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1993.

Construction Mechanic 1, NAVEDTRA 10645-F1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1989.

Construction Mechanic 3 & 2, NAVEDTRA 10644-G1, Naval Education Training Program Management Support Activity, Pensacola, FL, 1988.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Fundamentals of Service, Electrical Systems, 5th ed., Deere & Company, Moline, IL, 1984.

Fundamental of Service, Hydraulics, Deere & Company, Moline, IL, 1987.

Principles of Automotive Vehicles, TM 9-8000, Headquarters, Department of the Army, Washington, DC, 1988.

CHAPTER 5

California Commercial Driver Handbook, State of California, Department of Motor Vehicles, Sacramento, CA, 1991.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Federal Motor Carrier Safety Regulations Pocketbook, ORS-7A, U.S. Department of Transportation, Federal Highway Administration, Washington, DC, 1990.

Navy Driver's Handbook, NAVFAC MO-403, Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA, 1980.

CHAPTER 6

Embarkation Manual, COMSECOND/COMTHIRDNCBINST 3120.1, Naval Construction Brigade, Pearl Harbor, Hawaii, Naval Amphibious Base, Little Creek Norfolk, VA, 1983.

Equipment Management, COMSECOND/COMTHIRDNCBINST 11200.1, Department of the Navy, Naval Construction Battalions, U.S. Pacific Fleet, Pearl Harbor, Hawaii, Naval Construction Battalions, U.S. Atlantic Fleet, Naval Amphibious Base, Little Creek Norfolk, VA, 1988.

NCF Equipment Management Manual, NAVFAC P-404, Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA, 1988.

Equipment Operator, Advanced, NAVEDTRA 12537, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1993.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1987.

Facilities Planning Guide, NAVFAC P-437, Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA, 1990.

Federal Motor Carrier Safety Regulations Pocketbook, ORS-7A, U.S. Department of Transportation, Federal Highway Administration, Washington, DC, 1990.

MAC Affiliation Training Program, MAC Pamphlet 50-13, Department of the Air Force, Headquarters, Military Airlift Command, Scott Air Force Base, IL, 1987.

Management of Transportation Equipment, NAVFAC P-300, Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA, 1992.

Manual for Truck and Bus Drivers, Commercial Drivers License, Florida Department of Highway Safety and Motor Vehicles, Tallahassee, FL, 1989.

Navy Driver's Handbook, NAVFAC MO-403, Naval Facilities Engineering Command, 200 Stovall Street, Alexandria, VA, 1980.

Safety and Health Requirements Manual, EM 385-1-1, U.S. Army Corps of Engineers, Washington, DC, 1987.

CHAPTER 7

Apprentice Construction Equipment Operator, Volume 1, CDC 55131, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1984.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Manual for the Wheeled Vehicle Driver, Army Field Manual, FM 21-305, Air Force Regulation AFR 77-2, Headquarters, Department of the Army and Air Force, Washington, DC, 1984.

Manual for the Truck and Bus Driver, Commercial Drivers License, Florida Department of Highway Safety and Motor Vehicles, Tallahassee, FL, 1989.

Navy Driver's Handbook, NAVFAC MO-403, Naval Facilities Engineer Command, 200 Stovall Street, Alexandria, VA, 1980.

Nichols, Herbert L., Jr., *Moving the Earth,* 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Operator's Maintenance Manual, TM 5-2330-378-14 & P, Headquarters, Department of the Army, Washington, DC, 1988.

CHAPTER 8

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Lifting Operator's and Service Manual, LK 16000, Mainline Construction Equipment, 7135 Islington Avenue, Woodbridge, Ontario, 1985.

MAC Affiliation Training Program, MAC Pamphlet 50-13, Department of the Air Force, Headquarters, Military Airlift Command, Scott Air Force Base, IL, 1987.

Rough Terrain Forklift Truck, Model M4KN (4,000 Pounds), J. I. Case Company, Racine, WI, 1989.

CHAPTER 9

Case, 1085B Cruz-Air Excavator, Operator's Manual, J. I. Case Company, 2525 West Hampton Avenue, Milwaukee, WI, 1985.

Case, 480E Loader Backhoe, Operator's Manual, J. I. Case Company, 2525 West Hampton Avenue, Milwaukee, WI, 1986.

Ditcher Operations, SCBT 548.1, Naval Construction Training Center, GulfPort, MS, 1985.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1984.

International 510 Series B/515 Series B Payloader, Operator's Manual, International-Hough, East Sunnyside Avenue, Libertyville, IL, 1985.

Nichols, Herbert L., Jr., *Moving the Earth,* 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Pruess, E. D., *The Rubber Tired Tractor Shovel,* Construction Machinery Division, Clark Equipment Company, Benton Harbor, MI, 1989.

CHAPTER 10

Apprentice Construction Equipment Operator, Volume 1, CDC 131, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1984.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1984.

Equipment Utilization, U.S. Army Subcourse EN5468, U.S. Army Engineer School, Fort Belvoir, VA, 1988.

Lubrication and Maintenance Guide, 637 Tractor-Scraper, Caterpillar Tractor Company.

Nichols, Herbert L., Jr., *Moving the Earth,* 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Operator's Manual, John Deere 670A and 672A Motor Graders, John Deere Davenport Works, OM-T74697, Issue G3.

CHAPTER 11

Apprentice Construction Equipment Operator, Volume 1, CDC 55131, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1984.

Construction Equipment Operator, Volume 2, CDC 55151, “Earth Moving and Compaction,” Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1985.

Construction Mechanic 3 & 2, NAVEDTRA 10644-G1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1988.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1987.

Equipment Utilization, U.S. Army Subcourse EN5468, U.S. Army Engineer School, Fort Belvoir, VA, 1988.

Principles of Construction of Hot-Mix Asphalt Pavement, The Asphalt Institute Manual, Series No. 22, Asphalt Institute Building, College Park, MD, 1983.

CHAPTER 12

Cranes and Attachments 1, SCBT 540.1, Naval Construction Training Center, Gulfport, MS, 1988.

Crane and Attachments 2, SCBT 540.2, Information Sheet (Piledriver), Naval Construction Training Center, Gulfport, MS, 1980.

Crane Handbook, Construction Safety Association of Ontario, 74 Victoria Street, Toronto, Ontario, Canada, 1982.

Equipment Operator Advanced, NAVEDTRA 12537, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1993.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1984.

Mobile Crane Manual, Construction Safety Association of Ontario, 74 Victoria Street, Toronto, Ontario, Canada, 1982.

Naval Mobile Construction Battalion, Equipment Management, COMSECOND/COMTHIRDNCBINST 11200.1, Department of the Navy, Naval Construction Battalions, U.S. Pacific Fleet, Pearl Harbor, Hawaii, Naval Construction Battalions, U.S. Atlantic Fleet, Naval Amphibious Base, Little Creek, Norfolk VA, 1988.

Pile Construction, TM5-258, Department of the Army Technical Manual, Headquarters, Department of the Army, Washington, DC, 1963.

CHAPTER 13

Equipment Operator Advanced, NAVEDTRA 12537, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1993.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1984.

Rigging Manual, 1st ed., Construction Safety Association of Ontario, 74 Victoria Street, Toronto, Ontario, Canada, 1975.

Use of Wire Rope Slings and Rigging Hardware in the Naval Construction Force, COMSECOND/COMTHIRDNCBINST 11200.11, Department of the Navy, Naval Construction Battalions, U.S. Pacific Fleet, Pearl Harbor, Hawaii, Naval Construction Battalions, U.S. Atlantic Fleet, Naval Amphibious Base, Little Creek, Norfolk, VA, 1988.

Wire and Fiber Rope and Rigging, Naval Ship's Technical Manual, NAVSEA S9086-UU-STM-000/CH-613, Chapter 613, Commander, Naval Sea System Command, Washington, DC, 1978.

CHAPTER 14

Construction Electrician 3, NAVEDTRA 12523, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1993.

Equipment Operator, Advanced, NAVEDTRA 12537, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1993.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1984.

CHAPTER 15

Engineering Aid 3, NAVEDTRA 10696, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1991.

Equipment Operator Advanced, NAVEDTRA 12537, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1993.

Equipment Operator 3, NAVEDTRA 10692, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1990.

Equipment Operator 3 & 2, NAVEDTRA 10640-J1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1984.

Leveling Instruments, Linear Programmed Text Series 046/371C,Naval Construction Training Center, Port Hueneme, CA, 1990.

Naval Construction Battalion Crewleader's Handbook, COMSECOND/ COMTHIRDNCBINST 5200.X, Department of the Navy, Naval Construction Battalions, U.S. Pacific Fleet, Pearl Harbor, Hawaii, Naval Construction Battalions, U.S. Atlantic Fleet, Naval Amphibious Base, Little Creek Norfolk, VA, 1992.

Pavements Maintenance Specialist, Volume 2, CDC 55150, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1991.

Transferrings Elevations, Student Programmed Text Series 046/371D, Naval Construction Training Center, Port Hueneme, CA, 1988.

INDEX

A

Advance base planning, 6-34 to 6-37
  advance base functional components system, 6-34 to 6-35
  facilities planning guide, NAVFAC P-437, 6-35 to 6-37
Air brakes, 7-9 to 7-13
  brake drums, shoes, and linings, 7-9
  disc brakes, 7-9
  parking brake controls, 7-10
  s-cam air brakes, 7-9
  spring brakes, 7-10
  using air brakes, 7-10
  wedge brakes, 7-9
Air brake system, 3-24 to 3-26
  air compressor, 3-24
  air storage tanks, 3-25
  alcohol evaporator, 3-25
  brake pedal, 3-25
  governor, 3-24 to 3-25
  hand brake valve, 3-25 to 3-26
  pressure gauge, 3-25
  safety valve, 3-25
Air brakes, using, 7-10
  control braking, 7-10
  downhill braking, 7-10
  emergency stops, 7-10
  stab braking, 7-10
Air cleaners, 1-25 to 1-29
  dry air cleaners, 1-25 to 1-26
  dry-element air cleaners, 1-26 to 1-29
  oil bath air cleaners, 1-29
  pre-cleaners, 1-25
Air compressors, 14-7 to 14-10
  compressed air system, 14-8 to 14-9
  compressor capacity, 14-8
  compressor location, 14-8
  safety, 14-9 to 14-10
Air-cooling system, 1-36 to 1-38
  baffles and fins, 1-38
  fan and shroud, 1-38
Air induction system, 1-22 to 1-29
  air cleaners, 1-25 to 1-29
  blower, 1-22
  supercharger, 1-22 to 1-25
  turbochargers, 1-22
Air lines, trailer, 7-11
  emergency air lines, 7-11
  service air lines, 7-11
Asphalt, defects in flexible pavements, 16-16 to 16-20
  alligator cracks, 16-17
  bleeding aggregates, 16-20
  channeling, 16-19
  corrugations and shoving, 16-19
  cracking, 16-17
  depressions, 16-19
  disintegration, 16-20
  distortion, 16-18
  edge cracks, 16-17
  edge joint cracks, 16-17
  lane joint cracks, 16-17
  polished aggregates, 16-20
  potholes, 16-20
  raveling, 16-20
  reflection cracks, 16-18
  shrinkage cracks, 16-18
  slippage cracks, 16-18
  slippery surfaces, 16-20
  upheaval, 16-19 to 16-20
Asphalt distribute, 16-26 to 16-32
  attachments, 16-30 to 16-32
  falling tanks and distributors, 16-29 to 16-30
  heating bitumen in the distributor, 16-30
  heating system, 16-28
  safety, 16-32 to 16-33

Asphalt distributor—Continued
  spray bar adjustment, 16-28
  spray system, 16-28
  spraying, 16-30
Asphalt finishers (pavers), 16-34 to 16-44
  automatic screed controls, 16-40
  automatic screed controls, types and operating principles, 16-40 to 16-41
  automatic screed controls, selecting a reference system, 16-41
  bevel end plates, 16-42
  cutoff shoes, 16-42
  governors, 16-36 to 16-37
  hoppers, flow gates, and augers, 16-37
  maintenance, 16-42 to 16-43
  paver tires or tracks, 16-36
  paving safety, 16-43 to 16-44
  screed accessories, 16-41
  screed controls (adjustments), 16-39 to 16-40
  screed extensions, 16-41 to 16-42
  screed heaters, 16-41
  screed unit, 16-37 to 16-38
  tamping bar types of screeds, 16-38
  tons per hour, 16-42
  tractor unit (power unit), 16-36
  vibrating type of screeds, 16-38 to 16-39
Asphalt haul trucks, 16-33 to 16-34
  bottom-dump trucks, 16-34
  end-dump trucks, 16-33 to 16-34
  pivoted truck push rollers, 16-34
  truck condition, 16-33
  truck hitches, 16-34
  types of trucks, 16-33
Asphalt, pavement construction, 16-1 to 16-9
  asphalt-paving mixes, 16-1
  asphalt pavement structure, 16-2 to 16-3
  basic concepts, 16-1
  determining required pavement thickness, 16-4 to 16-5
  essential properties of asphalt-wearing surface, 16-3 to 16-4
Asphalt, pavement construction—Continued
  function of base course and subgrade, 16-4
  preparing asphalt for construction operations, 16-6
  prime coat, 16-6 to 16-7
  stage construction, 16-5
  subgrade evaluation, 16-5 to 16-6
  tack coat, 16-7 to 16-9
Asphalt, paving equipment, 16-25 to 16-44
  aggregate spreaders, 16-25 to 16-28
  asphalt distributor, 16-28 to 16-32
  asphalt distributor, safety, 16-32 to 16-33
  asphalt finisher (pavers), 16-34
  asphalt haul trucks, 16-33 to 16-34
  asphalt kettle, 16-32
  asphalt kettle, safety, 16-32 to 16-33
Asphalt, repairing defective flexible pavements, 16-21 to 16-22
  base course replacement, 16-21 to 16-22
  bituminous materials replacement, 16-22
  pavement cutting, 16-21
  pavement removal, 16-21
  removing defective flexible pavement, 16-21
Asphalt, surface treatments, 16-23 to 16-25
  aggregate application, 16-25
  aggregate surface treatment, 16-24
  binder application, 16-24 to 16-25
  fog seal, 16-23
  dust laying, 16-23
  multiple-surface treatment, 16-25
  purpose, 16-23
  road oiling, 16-23 to 16-24
  rolling, 16-25
  single-surface treatment, 16-24
  single-surface treatment, sequence of operations, 16-24
  sprayed asphalt surface treatment, 16-23
  types, 16-23
Asphalt, types of asphalt pavement construction, 16-9 to 16-16
  blade mixing, 16-15 to 16-16
  blade spreading, 16-11

Asphalt, types of asphalt pavement construction—Continued
  compacting plant-mix materials, 16-11 to 16-12
  compute plant-mix materials, 16-9 to 16-10
  hand spreading, 16-11
  mechanical spreading, 16-11
  mixed-in-place construction, 16-12
  placing plant-mix materials, 16-10 to 16-11
  plant-mix construction, 16-9
  road-mix pavements, 16-12 to 16-14
  road-mixing methods, 16-14
  travel plant mixing, 16-14 to 16-15
Attachment custodian, 6-24
Automatic transmission, 2-4 to 2-8
  fluid coupling, 2-5 to 2-6
  planetary gears, 2-6 to 2-7
  torque converter, 2-6
Automatic transmission operation, 2-7 to 2-8
  d-drive position, 2-7
  l-low position or power position, 2-7
  n-neutral position, 2-7
  p-park position, 2-7
Auxiliary lights, 4-5
  backup lights, 4-5
  parking lights, 4-5
  spotlights, 4-5
Auxiliary transmission, 2-8 to 2-9
  power takeoffs, 2-9
  transfer cases, 2-8 to 2-9

B

Battery, 4-1 to 4-2
  battery capacity, 4-2
  battery construction, 4-1 to 4-2
Bituminous rolling, 11-25 to 11-29
  breakdown rolling, 11-27 to 11-29
  cold joints, 11-27
  finish rolling, 11-29
Bituminous rolling—Continued
  hot joints, 11-27
  intermediate rolling, 11-29
  longitudinal joints, 11-26
  transverse joints, 11-26
Blower, 1-22
Brake systems, 3-21 to 3-27
  air brake system, 3-24 to 3-26
  air-over-hydraulic brake system, 3-26 to 3-27
  disc brakes, 3-22
  external contracting brakes, 3-21 to 3-22
  hydraulic brake system, 3-23 to 3-24
  individual brakes, 3-21
  internal expanding brakes, 3-22
  mechanical parking brake, 3-22 to 3-23
  vacuum brakes, 3-27
Bus driver, 6-28 to 6-30
  prohibited practices, 6-30
  transportation of personnel, 6-30

C

Carburetor, 1-18 to 1-21
Catalytic converter, 1-14
Chain, 13-15
  chain grades, 13-15
  chain strength, 13-15
  handling and care of chain, 13-15
Charging system, 4-2 to 4-3
  ac charging system, 4-2
  charging system, 4-2 to 4-3
  dc charging system, 4-2
Cold weather starting aids, 1-21 to 1-22
  glow plugs, 1-22
  preheater, 1-21
Collateral equipage custodian, 6-22 to 6-24
  component collateral equipage, 6-23
  tactical collateral equipage, 6-23

Concrete transit mixer, 14-1 to 14-3
  cleaning, 14-2 to 14-3
  discharge chutes, 14-1 to 14-2
  operation, 14-2
  safety, 14-3
Construction (grade) stakes, 15-15 to 15-20
  centerline stakes, 15-17
  cut-and-fill stakes, 15-18 to 15-20
  finish grade stakes, 15-20
  line stakes, 15-17
  shoulder stakes, 15-18
  slope stakes, 15-20
  starting point, 15-16 to 15-17
  right-of-way stakes, 15-20
Crane attachments, 12-16 to 12-20
  clamshell, 12-17 to 12-18
  dragline, 12-18 to 12-20
  hook block, 12-16
Crane operations, 12-20 to 12-35
  clamshell operations, 12-34
  crane crew, 12-20 to 12-21
  crane lift checklist, 12-28
  crane operator's daily inspection, 12-21 to 12-23
  crane stability, 12-28 to 12-31
  dragline employment, 12-35
  dragline operations, 12-34 to 12-36
  efficient dragline operation, 12-35 to 12-36
  hook block inspection, 12-24
  load capacity, 12-31 to 12-32
  load rating chart, 12-32
  operator, 12-21
  rigger, 12-21
  safe lifting, 12-32 to 12-34
  sheave inspection, 12-24 to 12-26
  signalman, 12-21
  wire rope end connections, 12-26 to 12-28
  wire rope inspection, 12-23 to 12-24
Cranes, 12-1 to 12-16
  boom angle indicators, 12-7 to 12-9
  boom mast, 12-10
  boom pendants, 12-9
  boom sections, 12-6 to 12-7
  boom stops, 12-10
  bridle assembly, 12-10
  counterweight, 12-12
  crawler-mounted cranes, 12-1 to 12-3
  engine, 12-11 to 12-12
  gantry, 12-9 to 12-10
  hoisting mechanism, 12-11
  house assembly, 12-10 to 12-12
  jib and extension, 12-9
  lattice boom breakdown, 12-12 to 12-15
  lattice boom crane, 12-6 to 12-15
  operator's cab, 12-10 to 12-11
  sheaves, 12-9
  telescopic boom crane, 12-15 to 12-16
  telescopic boom crane, counterweight, 12-16
  telescopic boom crane, hoisting mechanism, 12-16
  telescopic boom crane, house assembly, 12-16
  telescopic boom crane, operator's cab, 12-16
  telescopic boom crane, power source, 12-16
  telescopic boom crane, sections, 12-16
  truck-mounted cranes, 12-3 to 12-5
  types of cranes, 12-1 to 12-6
  wheel-mounted cranes, 12-5 to 12-6
Cranes, pile-driving operations, 12-36 to 12-48
  base assembly, 12-46 to 12-47
  cylinder, 12-46
  diesel hammer operation, 12-42 to 12-43
  extended four-way leads, 12-39 to 12-41
  fuel system, 12-44 to 12-45
  leads, 12-36 to 12-41
  lubrication system, 12-45 to 12-46

Cranes, pile-driving operations—Continued
  pile-driving caps, 12-47
  pile-driving hammers, 12-41 to 12-48
  placing hammer in leads, 12-47 to 12-48
  ram-piston overstroke, 12-47
  spud leads, 12-41
  swinging leads, 12-37 to 12-39
  trip mechanism, 12-43 to 12-44
  underhung leads, 12-39
Cranes, pile-driving techniques and terminology, 12-48 to 12-55
  driving bearing piles in groups, 12-48 to 12-49
  obstruction and refusal, 12-49 to 12-50
  pulling piles, 12-50 to 12-51
  springing and bouncing, 12-48
  straightening and aligning piles, 12-50
  types of piles, 12-51 to 12-55
Crawler-mounted rock drill, 14-15 to 14-22
  adding extension rods, 14-21
  air system, 14-17
  boom, 14-17 to 14-18
  control console, 14-17
  drill guide, 14-18
  drill mounting, 14-18
  drill mounting plate, 14-18
  drilling, 14-19 to 14-20
  drilling operation, 14-20 to 14-21
  dump and swing assembly, 14-18
  feed chain, 14-18
  feed motor assembly, 14-18
  guide swing and extension mounting, 14-18
  hose reel plate, 14-18
  hydraulic system, 14-16 to 14-17
  main frame, 14-15
  oil cooler, 14-17
  positioning for drilling, 14-20
  power unit, 14-16
Crawler-mounted rock drill—Continued
  removing extension rods, 14-21 to 14-22
  safety, 14-22
  traction drive, 14-15 to 14-16
  traveling, 14-18 to 14-19
Crete mobile, 14-3 to 14-4

D

Defensive driving, 5-1 to 5-2
  avoiding rear-end collisions, 5-1
  correcting a skid, 5-2
  speed limits, 5-1
Diesel engine, four stroke, 1-4 to 1-8
Diesel engine, two stroke, 1-10 to 1-11
Diesel fuel, 1-14 to 1-15
Diesel fuel filters, 1-16 to 1-17
  primary filter, 1-17
  secondary filter, 1-17
Diesel fuel system, 1-21 to 1-22
  cold weather starting aids, 1-21 to 1-22
  fuel transfer pump, 1-21
  injection nozzles, 1-21
  injection pump, 1-21
Dispatch forms, 6-8 to 6-15
  DD Form 518, 6-15
  DD Form 1970, 6-10
  NAVFAC 9-11240/13, 6-10
  NAVFAC 11260/4, 6-10
  Standard Form 91, 6-10
Dispatching, 6-16 to 6-20
  dispatcher's log, 6-16 to 6-20
  duties of the dispatcher, 6-16
  equipment status board, 6-16
  trouble reports file, 6-20
Ditchers, 9-29 to 9-34
  capabilities and limitations of ditchers, 9-32
  chain ditcher, 9-32
  cutting curves, 9-33

Ditchers—Continued
- ladder ditcher, 9-31 to 9-32
- muddy trenching, 9-33
- operating techniques, 9-32 to 9-33
- safety, 9-34
- transporting, 9-33 to 9-34
- wheel ditcher, 9-30
- wheel ditcher, digging, 9-30 to 9-31
- wheel ditcher, obstructions, 9-31

Dozer, 11-1 to 11-10
- angle blade, 11-8
- attachments, 11-5 to 11-10
- dozer blades, 11-6 to 11-8
- front idler, 1-4
- lubrication, 11-5
- recoil spring, 11-4
- rippers, 11-9
- straight blade, 11-7 to 11-8
- track adjusting mechanism, 11-4 to 11-5
- track adjustment, 11-5
- track assembly, 11-2
- track chain, 11-2 to 11-3
- track frame, 11-3
- track frame rollers, 11-3 to 11-4
- track shoes, 11-3
- tracks and track frame, 11-2 to 11-5
- “u” blade, 11-8
- winches, 11-9 to 11-10

Dozer, operating techniques, 11-10 to 11-19
- backfilling, 11-15
- brush and trees, 11-10 to 11-12
- bulldozing, 11-13 to 11-15
- clearing, 11-10 to 11-13
- ditching, 11-15 to 11-16
- finishing, 11-15
- finishing side slopes, 11-17 to 11-18

Dozer, operating technique—Continued
- push dozer, 11-18
- removing rocks and boulders, 11-13
- safety, dozer, 11-18 to 11-19
- side-by-side dozing, 11-14
- sidehill excavation, 11-16 to 11-17
- slot dozing, 11-14
- spreading, 11-15
- stumping, 11-12
- working in wet material, 11-13

Driving under hazardous conditions, 5-5 to 5-6
- fog and smoke, 5-6
- night driving, 5-6
- snow and ice, 5-5 to 5-6
- wet roads, 5-6

Driving under normal conditions, 5-2 to 5-5
- backing up, 5-3
- expressway, 5-4
- parking, 5-3
- passing, 5-2
- periodic stop, 5-4 to 5-5
- turning, 5-2

Driving under special conditions, 5-6 to 5-8
- cross-country, 5-7
- driving hours, 5-7
- mountain driving, 5-7 to 5-8
- sand, 5-7

Dump trucks, 7-30 to 7-33
- characteristics, 7-31
- dump truck operations, 7-31

E

Earth augers, 14-4 to 14-7
- augers, 14-6 to 14-7
- drilling, 14-7
- drilling and retracting, 14-5 to 14-6
- leveling, 14-5

Earth augers—Continued
  operations, 14-5 to 14-6
  raising and lowering, 14-5
  safety, 14-7
Earthwork computations, 15-10 to 15-15
  cross sections, 15-13 to 15-15
  road nomenclature, 15-10 to 15-12
  slope ratio, 15-12
  volume changes, 15-10
Electrical system, 4-1 to 4-7
  charging system, 4-2 to 4-3
  fuses, 4-5 to 4-6
  gauges, 4-6 to 4-7
  lighting system, 4-3 to 4-6
  starting circuits, 4-3
  storage battery, 4-1
Embarkation, 6-32 to 6-34
  CESE and material preparation, 6-32
  mobile loads, 6-32
  on-board fuel, 6-32 to 6-34
  palletized cargo, 6-34
Engine cooling system, 1-32 to 1-38
  air-cooling system, 1-36 to 1-38
  liquid-cooling system, 1-32 to 1-38
Engine cycle, 1-3
  compression, 1-3
  exhaust, 1-3
  intake, 1-3
  power, 1-3
Engines, internal combustion, 1-1 to 1-12
  four-stroke cycle diesel, 1-4 to 1-8
  four-stroke cycle gasoline, 1-3 to 1-4
  multi-fuel, 1-8 to 1-9
  two-stroke cycle diesel, 1-10
Engine oil, 1-29
  filtering system, 1-31
  oil filters, 1-30
Engine oil—Continued
  oil level indicator, 1-29 to 1-30
Excavator, attachments, 9-24 to 9-26
  boom, 9-24
  bucket, 9-26
  bucket mounting, 9-25 to 9-26
  dipper stick, 9-24 to 9-25
Excavator, travel unit, 9-23 to 9-24
  self-propelled wheel mounted, 9-24
  track mounted, 9-23
  truck mounted, 9-23 to 9-24
Excavators, 9-21 to 9-29
  attachments, 9-24 to 9-26
  digging procedures, 9-26
  foundation excavation, 9-27 to 9-29
  job layout, 9-27
  revolving unit, 9-23
  safety, 9-29
  travel unit, 9-23

F

Fiber line, 13-13 to 13-15
  cotton, 13-13
  handling and care of fiber line, 13-14
  hemp, 13-13
  inspection of fiber line, 13-14 to 13-15
  kevlar, 13-14
  manila, 13-13
  nylon, 13-13 to 13-14
  sisal, 13-13
  types of fiber line, 13-13
Filtering system, 1-31
  bypass system, 1-31
  full-flow system, 1-31
Final drives, 2-10 to 2-11
  differentials, 2-11 to 2-12
  driving axles, 2-12 to 2-13

Final drives—Continued
  driving wheels, 2-13
Floodlights, 14-22 to 14-23
  components, 14-22
  operation, 14-22
  safety, 14-23
Forklift, attachments, 8-6
  crane boom attachment, 8-6
  drum-handling attachment, 8-6
  fork extensions, 8-6
Forklift, capabilities and limits, 8-8 to 8-15
  capacity, 8-8 to 8-10
  carrying, pallets and boxes, 8-10 to 8-15
  lift height, 8-8
  lifting, pallets and boxes, 8-10
Forklifts, 8-1 to 8-15
  attachments, 8-6
  capabilities and limits, 8-8 to 8-15
  lift-king forklift, 8-5
  material-handling equipment, 8-1
  4K rough-terrain (RT) forklift, 8-2 to 8-4
  6K rough-terrain (RT) forklift, 8-4 to 8-5
  principles of operation, 8-6 to 8-8
  warehouse forklifts, 8-1 to 8-2
Four-stroke cycle diesel engine, 1-4 to 1-8
  diesel engine compression stroke, 1-8
  diesel engine exhaust stroke, 1-8
  diesel engine intake stroke, 1-7
  diesel engine power stroke, 1-8
Four-stroke cycle gasoline engine, 1-3 to 1-4
  exhaust stroke, 1-4
  compression stroke, 1-4
  intake stroke, 1-4
  power stroke, 1-4
Front-end loader, attachments, 9-2 to 9-5
  backhoe, 9-5
  buckets, 9-4 to 9-5
Front-end loader, attachment—Continued
  forklift, 9-5
Front-end loader, backhoe operations, 9-14 to 9-21
  515 dresser backhoe, 9-14 to 9-16
  loader backhoe, 9-16 to 9-21
Front-end loaders, 9-1 to 9-21
  attachments, 9-2 to 9-5
  automatic bucket leveler, 9-6
  backhoe operations, 9-14 to 9-21
  crawler-mounted front-end loader, 9-1 to 9-2
  improper uses of the multipurpose bucket, 9-12 to 9-14
  loader operation, 9-9 to 9-12
  operating techniques, 9-5 to 9-6
  position indicator, 9-6 to 9-8
  rubber-tired front-end loader, 9-1
Fuel filters, 1-15 to 1-18
  diesel fuel filters, 1-16 to 1-17
  gasoline fuel filter, 1-15 to 1-16
Fuel-handling vehicle, 6-25 to 6-27
  description, 6-25 to 6-26
  operation, 6-26 to 6-27
Fuel systems, 1-13 to 1-22
  diesel fuel, 1-14 to 1-15
  fuel tanks, 1-13 to 1-14
  gasoline fuel, 1-14
Fuel transfer pump, 1-21
Fuel truck driver, 6-24 to 6-28
  fuel-handling vehicles, 6-25 to 6-27
  fuel safety, 6-27 to 6-28

G

Gasoline fuel, 1-14
  catalytic converter, 1-14
Gasoline fuel system, 1-18 to 1-21
  carburetor, 1-18 to 1-21
  fuel pump, 1-18

Gauges, 4-6 to 4-7
  air pressure gauge, 4-7
  hydraulic pressure gauge, 4-7
  hydraulic temperature gauge, 4-7
  fuel level gauge, 4-7
  oil pressure gauge, 4-7
  water temperature gauge, 4-6 to 4-7
Gear oil, 1-31
Generators, 14-24 to 14-26
  cleaning, 14-26 to 14-27
  generator watch, 14-26
  operation, 14-24 to 14-26
Graders, 10-1 to 10-6
  articulated frame steering, 10-2 to 10-3
  circle, 10-5
  drawbar, 10-5
  frame, 10-3
  grader components, 10-1
  moldboard, 10-3 to 10-5
  prime mover, 10-2
  scarifier, 10-5 to 10-6
  tandem drive, 10-2
Grader operations, 10-6 to 10-16
  blade pitch, 10-9 to 10-10
  crown, 10-12 to 10-13
  ditch cut, 10-11 to 10-12
  finish grading, 10-14 to 10-15
  flat-bottom ditch cut, 10-12
  grader estimates, 10-15
  high bank cuts, 10-13
  road maintenance, 10-14
  safety, grader, 10-16
  scarifying, 10-10
  snow removal, 10-14
  turning around, 10-7 to 10-9
  wheel lean, 10-6 to 10-7
  wide side reach (spreading), 10-13 to 10-14
Grease, 1-31 to 1-32

H

Hydraulic brake system, 3-23 to 3-24
Hydraulic cylinders, 4-9 to 4-10
  double-acting cylinders, 4-9 to 4-10
  single-acting cylinders, 4-9
Hydraulic fluid, 1-31
Hydraulic systems, 4-7 to 4-12
  accumulators, 4-11 to 4-12
  control valves, 4-9
  flexible hoses, 4-10 to 4-11
  hydraulic cylinders, 4-9 to 4-10
  hydraulic motors, 4-12
  hydraulic pumps, 4-9
  hydraulic reservoir, 4-8 to 4-9
  quick-disconnect couplers, 4-11
  strainers and filters, 4-9

I

Internal combustion engines, 1-1 to 1-12
Injection nozzles, 1-21
Injection pump, 1-21
International signals and road signs, 5-12 to 5-13
  colors, 5-12
  pavement markings, 5-12
  shapes, 5-12

J

Jet fuel, 1-15

L

Leveling equipment, 15-21 to 15-34
  bench marks, 15-27 to 15-28
  checking grade with a level instrument, 15-30
  determining elevations, 15-28 to 15-30
  direct reading, 15-25 to 15-26
  dumpy level, 15-23
  errors and mistakes, 15-34

Leveling equipment—Continued
    hand level, 15-21 to 15-23
    level rod, 15-25
    leveling, 15-27
    measuring horizontal distances, 15-32 to 15-33
    missing a grade stake, 15-30 to 15-32
    self-leveling level, 15-23 to 15-24
    target reading, 15-26 to 15-27
    tripod, 15-24
    turning point, 15-32
License, 6-1 to 6-7
    application forms, 6-1
    automotive test, 6-7
    construction equipment test, 6-7
    license test, 6-1 to 6-7
    material-handling equipment test, 6-7
    performance qualification test, 6-7
    standard form 47, 6-1
License forms, 6-7 to 6-8
    construction equipment operator license, NAVFAC 11260/2, 6-8
    U.S. government motor vehicle operator's identification card OF-346, 6-7 to 6-8
Lighting system, 4-3 to 4-6
    auxiliary lights, 4-5 to 4-6
    clearance lights, 4-4 to 4-5
    lamps and bulbs, 4-4
    reflectors, 4-5
    side marker lights, 4-5
    taillights and brake lights, 4-5
Liquid-cooling system, 1-32 to 1-36
    expansion tank, 1-36
    fan and shroud, 1-35
    overflow tank, 1-36
    radiator, 1-32 to 1-33
    thermostat, 1-35 to 1-36
    water jacket, 1-35
    water pump, 1-34
Loading equipment, 7-26 to 7-27
    detachable gooseneck trailer, 7-27
    low-bed trailer, 7-26
    tilt-bed trailer, 7-26 to 7-27
Lubrication system, 1-29 to 1-32
    engine oil, 1-29
    filtering systems, 1-31
    gear oil, 1-31
    grease, 1-31 to 1-32
    hydraulic fluid, 1-31
    oil filters, 1-30
Lubricators, 14-27 to 14-28
    safety, 14-28
    uses, 14-28

M

Manual transmission, 2-2 to 2-4
    clutch shifting, 2-4
    double-clutch shifting, 2-4
    manual shift operation, 2-3 to 2-4
Mechanical advantage, 13-23
    block and tackle, 13-23 to 13-25
    block safety, 13-25
    block to line ratio, 13-25
    chain hoist, 13-25 to 13-26
    ground angle, 13-27
    fleet angle, 13-27
    winches, 13-26 to 13-27
Mobile concrete mixer plant, 14-3 to 14-4
    operation, 14-3 to 14-4
    safety, 14-4
Mountain driving, 5-7 to 5-8
    escape ramps, 5-8
    proper braking, 5-7 to 5-8
    use of gears, 5-7

O

Oil filters, 1-30
  cartridge filter, 1-30
  sealed (spin-on) filter, 1-30

P

Pneumatic tools, 14-10 to 14-15
  asphalt cutter, 14-11
  chain saw, 14-14
  chisel point, 14-11
  circular saw, 14-14
  clay spade, 14-11
  drill, 14-14
  hand-held rotary rock drill/jackhammer, 14-12 to 14-13
  hand-held rotary rock drill/jackhammer, safety, 14-13
  moil point, 14-11
  nail driver, 14-14
  pavement breaker/jackhammer, 14-10 to 14-12
Project planning, 15-1 to 15-10
  civil pages, 15-5 to 15-7
  index pages, 15-5
  project drawings, 15-3
  project drawings, pages, 15-3 to 15-5
  project drawings, symbols, 15-7 to 15-8
  sketches, 15-8 to 15-10
Propeller shaft assemblies, 2-9 to 2-10
  center support bearings, 2-10
  universal joints, 2-10
Pumps, 14-28 to 14-30
  centrifugal pump, 14-29 to 14-30
  centrifugal pump, inspection, 14-30
  centrifugal pump, operation, 14-30
  diaphragm pump, 14-28 to 14-29
  diaphragm pump, inspection, 14-29
  diaphragm pump, operation, 14-29

R

Radiator, 1-32 to 1-33
  coolant and antifreeze, 1-34
  radiator pressure cap, 1-33 to 1-34
Rigging safe operating procedures, 13-27 to 13-28
Rollers, 11-19 to 11-24
  impact forces, 11-20
  pneumatic-tired rollers, 11-22 to 11-23
  sheepsfoot drum, 11-20
  smooth drum, 11-20 to 11-22
  steel-wheeled rollers, 11-23 to 11-23
  vibration response, 11-20
  vibratory roller, 11-19 to 11-20
  weight, 11-20
Rolling techniques, 11-24 to 11-29
  bituminous rolling, 11-25 to 11-29
  breakdown rolling, 11-27 to 11-29
  changing direction and speed, 11-24
  cold joints, 11-27
  finish rolling, 11-29
  hot joints, 11-27
  intermediate rolling, 11-29
  longitudinal joints, 11-26
  roller safety, 11-29
  rolling sequence, 11-24 to 11-25
  steering, 11-24
  transverse joints, 11-26

S

Saltwater operations, 6-21 to 6-22
  after operations service, 6-21
  operating precautions, 6-21
  preinspection, 6-21
  recovery procedures, 6-21 to 6-22
Safety
  air compressors, 14-9 to 14-10
  asphalt distribute, 16-32 to 16-33

Safety—Continued
  asphalt kettle, 16-32 to 16-33
  concrete transit mixer, 14-3
  crawler-mounted rock drill, 14-22
  ditcher, 9-34
  dozer, 11-18 to 11-19
  earth augers, 14-7
  excavator, 9-29
  floodlights, 14-23
  fuel truck, 6-27 to 6-28
  grader, 10-16
  hand-held rotary rock drill/jackhammer, 14-13
  lubricators, 14-28
  mobile concrete mixer plant, 14-4
  pneumatic tools, 14-14 to 14-15
  rigging, 13-27 to 13-28
  roller, 11-29
  scraper, 10-27 to 10-28
  tires, 3-20
  tractor-trailers, 7-20 to 7-23
Scrapers, 10-16 to 10-20
  apron, 10-19
  bowl, 10-19
  control levers, 10-20
  ejector, 10-19
  scraper components, 10-18 to 10-19
Scraper operations, 10-20 to 10-28
  back-track loading, 10-24
  chain loading, 10-25
  downhill loading, 10-24
  haul roads, 10-26
  hauling, 10-22
  large objects, 10-23 to 10-24
  loose sand and gravel, 10-23
  optimum loading, 10-25 to 10-26
  production techniques, 10-24 to 10-27
Scraper operations—Continued
  returning to the cut, 10-22
  safety, scraper, 10-27 to 10-28
  scraper spacing efficiently, 10-26 to 10-27
  spreading, 10-27
  spreading or unloading, 10-22
  shuttle loading, 10-24
  straddle loading, 10-24
  turns, 10-26
  wet and sticky materials, 10-22 to 10-23
  working difficult materials, 10-22 to 10-24
Securing cargo, 7-27 to 7-30
  binders, 7-29
  building materials, 7-28
  chains, 7-29
  equipment, 7-29
  loose material, 7-28
  oversize an overweight loads, 7-29 to 7-30
  restraints, 7-28 to 7-29
Slings, 13-16 to 13-23
  chain slings, 13-16
  fiber line slings, 13-16
  proof testing slings, 13-22
  records, 13-22
  sling angle, 13-17
  sling inspection, 13-21 to 13-22
  sling safe working loads, 13-19 to 13-21
  spreader bars, 13-19
  storage, 13-23
  using wire rope and fiber slings, 13-16 to 13-17
  wire rope slings, 13-16
Snow removal equipment, 14-32 to 14-35
  blowers, 14-34
  combination blade, 14-33 to 14-34
  graders, 14-34
  loaders, 14-35
  plows, 14-33

Snow removal equipment—Continued
  reversible blade, 14-33
  roll-over blade, 14-33
  sand spreaders, 14-35
Soils, 15-34 to 15-37
  coarse-grained soils, 15-35
  fine-grained soils, 15-35
  organic soils, 15-35
  soil classification, 15-35
  soil compaction, 15-36 to 15-37
  soil formation, 15-34
  soil gradation, 15-36
  soil profile, 15-34
  soil properties, 15-34
  soil sizes, 15-35 to 15-36
  soil stabilization, 15-37
Springs, 3-5 to 3-6
  coil springs, 3-6
  multiple leaf springs, 3-5 to 3-6
Starting circuits, 4-3
  parallel system, 4-3
  series-parallel system, 4-3
  series system, 4-3
Steering systems, 3-1 to 3-4
  articulated steering, 3-2
  front-and-rear steering, 3-2 to 3-4
  power steering, 3-2
  steering mechanisms, 3-1 to 3-2
Superchargers, 1-22 to 1-25
  centrifugal supercharger, 1-25
  roots supercharger, 1-25
  vane supercharger, 1-25
Suspension system, 34 to 3-7
  front axle suspension, 3-7
  rear axle suspension, 3-7
  shock absorbers, 3-6
  springs, 3-5 to 3-6
Sweepers, 14-30 to 14-32
  magnetic sweeper, 14-31 to 14-32
  street sweeper, 14-31
  towed sweeper, 14-31

T

Techniques of earthwork operations, 15-37 to 15-42
  base course, 15-42
  clearing, 15-39
  drainage, 15-40 to 15-42
  grading and excavating, 15-42
  grubbing, 15-39 to 15-40
  equipment, 15-38 to 15-39
  pioneering, 15-39
  placement and compaction, 15-42
  stripping, 15-40
Time cards, 6-30 to 6-32
Tree, inflation, 3-7 to 3-8
  overinflated, 3-8
  properly inflated, 3-7
  underinflated, 3-8
Tire repair, 3-13 to 3-20
  cold patches, 3-19 to 3-20
  earthmover tire repair, 3-17 to 3-19
  hot patches, 3-20
  tubeless tire repair, 3-16 to 3-17
Tire, types of tire treads, 3-11 to 3-13
  cross-country tread, 3-11
  directional tread, 3-11
  earthmover tread, 3-12
  nondirectional tread, 3-11
  regular tread, 3-11 to 3-12
  rock service tread, 3-12
Tire, valves, 3-8 to 3-9
  valve caps, 3-8 to 3-9
  valve cores, 3-8

Tires, 3-7 to 3-20
  tire inspection, 3-7 to 3-11
  tire removal, 3-12 to 3-13
  tire repair, 3-13 to 3-20
  types of tire treads, 3-11 to 3-13
  tire rotation, 3-20
  tire safety, 3-20
Tires, mechanical irregularities, 3-10 to 3-11
Tires, mismatching, 3-9 to 3-11
  bias-ply tires, 3-10
  radial-ply tires, 3-9
Tractor-trailers, 7-1 to 7-13
  air brakes, 7-9 to 7-13
  brake test, 7-8 to 7-9
  cab inspection, 7-8
  engine compartment, 7-6
  hose couplers, 7-11
  prestart inspection, 7-4 to 7-6
  shutoff valves, 7-11 to 7-12
  tractor protection valve, 7-10
  trailer air lines, 7-11
  trailer air tanks, 7-12
  trailer hand valve, 7-10
  types of trailers, 7-1 to 7-4
  vehicle overview, 7-6
  walk-around inspection, 7-6 to 7-8
Tractor-trailer, operation, 7-13 to 7-23
  automatic transmissions, 7-19
  accelerating, 7-18
  backing, 7-20
  coupling and uncoupling, 7-14 to 7-18
  fifth wheel assembly, 7-13 to 7-14
  left turns, 7-20
  loading and securing cargo, 7-23
  loading cargo, 7-25 to 7-26
  loading equipment, 7-26 to 7-27
Tractor-trailer, operation—Continued
  multi-speed rear axles and auxiliary transmissions, 7-18
  operating conditions, 7-23
  oversize and overweight loads, 7-29 to 7-30
  restraints, 7-28 to 7-29
  retarders, 7-19
  right turns, 7-19
  safety, 7-20 to 7-23
  securing cargo, 7-27 to 7-30
  steering, 7-18
  turns, 7-19
  vehicle weight definitions, 7-23
  weight distribution, 7-25
Trailers, types, 7-1 to 7-4
  detachable gooseneck trailer, 7-4
  low-bed trailer, 7-3
  stake trailer, 7-2 to 7-3
  tilt-bed trailer, 7-3
  van trailer, 7-2
Transmissions, 2-1 to 2-9
  automatic transmission, 2-4 to 2-7
  auxiliary transmission, 2-8 to 2-9
  clutch, 2-1 to 2-2
  manual shaft operation, 2-3 to 2-4
  manual transmission, 2-2 to 2-3
Transportation administration, 6-1 to 6-15
  dispatch forms, 6-8 to 6-15
  license, 6-1 to 6-7
  license forms, 6-7 to 6-8
Transportation pool, 6-15 to 6-32
  attachment custodian, 6-24
  bus driver, 6-28 to 6-30
  collateral equipage custodian, 6-22 to 6-24
  dispatching, 6-16 to 6-20
  fuel truck driver, 6-24 to 6-28
  taxi driver, 6-30

Transportation pool—Continued
  time cards, 6-30 to 6-32
  yard boss, 6-20 to 6-22
Truck, operating conditions, 7-23 to 7-25
  ideal condition, 7-25
  moderate condition, 7-25
  severe condition, 7-25
Two-stroke cycle diesel engine, 1-10
  compression stroke, 1-10
  power stroke, 1-10
Turbocharger, 1-22

V

Valve train, 1-10 to 1-13
Vehicle recovery, 5-8 to 5-11
  self-and-like vehicle recovery, 5-11 to 5-12
  wreckers, 5-8 to 5-10

W

Water pump, 1-35
Wire rope, 13-1 to 13-10
  abrasion resistance, 13-4
  characteristics of wire rope, 13-4
  coiling and uncoiling, 13-5
  corrosion resistance, 13-4
  crushing strength, 13-4
  drum winding, 13-7 to 13-8
  fatigue resistance, 13-4
  fleet angle, 13-8
  grades of wire rope, 13-2 to 13-3
  handling and care of wire rope, 13-5
  improved plow steel wire rope, 13-3
  kinks, 13-6 to 13-7
  lay length of wire rope, 13-3
  lays of wire rope, 13-3
Wire rope—Continued
  maintenance of wire rope, 13-9 to 13-10
  measuring wire rope, 13-4 to 13-5
  mild plow steel wire rope, 13-2
  plow steel wire rope, 13-3
  reverse bends, 13-8 to 13-9
  seizing and cutting, 13-9
  sizes of sheaves, 13-8
  strand, 13-1 to 13-2
  tensile strength, 13-4
  wire, 13-1
  wire rope failure, 13-5
  wire rope safe working load, 13-5
Wire rope attachments, 13-10 to 13-13
  hooks and shackles, 13-12 to 13-13
  speltered socket, 13-11
  swaged connections, 13-12
  thimble, 13-12
  wedge socket, 13-10 to 13-11
  wire rope clips, 13-11
Wreckers, 5-8
  cross-country tow, 5-10
  highway tow, 5-10
  mired truck, 5-8
  nosed truck, 5-8 to 5-9
  overturned truck, 5-9 to 5-10
  towing, 5-10

Y

Yard boss, 6-20 to 6-22
  preventive maintenance, 6-21
  saltwater operations, 6-21 to 6-22
  tool kit, 6-20 to 6-21
  washrack, 6-21

* U.S. G.P.O.:1995-355-634

Assignment Questions

Information: The text pages that you are to study are provided at the beginning of the assignment questions.

ASSIGNMENT 1

Textbook Assignment: “Engine Systems” and “Power Train” pages 1-1 through 2-7.

Learning Objective: Recognize the principles and components of internal combustion engines.

1-1. An engine is a device that converts what type of energy into mechanical energy to perform work?

1. Reciprocating
2. Physical
3. Heat
4. Kinetic

1-2. What is the name of the chemical reaction that occurs when the air and fuel mixture in a cylinder is ignited?

1. Combustion
2. Explosion
3. Detonation
4. Convulsion

1-3. The connecting rod transmits the up-and-down motion of the cylinder to the crankshaft.

1. True
2. False

1-4. The movement of a piston from top to bottom or from bottom to top is known by what term?

1. The top dead center
2. The bottom dead center
3. The timing
4. A stroke

1-5. What total number of the intake, compression, power, and exhaust series of events must occur to equal a cycle?

1. One
2. Two
3. Three
4. Four

1-6. During the intake stroke, in a four-stroke cycle gasoline engine, what condition is created in the cylinder by the downward movement of the piston?

1. Compression
2. Vacuum
3. Combustion
4. Expansion

1-7. To what volume is the fuel and air mixture compressed in a diesel engine?

1. One eighth
2. One fifteenth
3. One twentieth
4. One twenty-fifth

1-8. In a four-stroke cycle diesel engine, air and fuel are mixed in what component?

1. The combustion chamber
2. The injection system
3. The catalytic converter
4. The carburetor

1-9. The diesel engine develops greater torque than a gasoline engine due to the power developed from the low-compression ratio.

1. True
2. False

1-10. What term is used to describe the system of a two-stroke diesel engine taking in air and discharging exhaust?

1. Supercharging
2. Turbocharging
3. Scavenging
4. Blowing

1–11. If the exhaust valve opened in the middle of the intake stroke, the piston would draw burnt gases into the combustion chamber with a fresh mixture of fuel and air.

1. True
2. False

1-12. What part of the camshaft contacts the bottom of the lifter?

1. Cam bearing
2. Cam valve tappet
3. Cam timing gear
4. Cam lobe

Learning Objective: Recognize the principles and components of fuel systems.

1-13. The function of the fuel system is to ensure a quantity of clean fuel is confined from the fuel intake of an engine?

1. True
2. False

1–14. What type of harmful pollution is emitted in great amounts into the atmosphere by engines that use leaded gasoline?

1. Hydrocarbons
2. Sodium Aluminate
3. Hydrogen sulfide
4. Carbon dioxide

1-15. What number designator is used to identify the ability of gasoline to burn evenly and resist spontaneous combustion?

1. Cetane
2. Ratio
3. Octane
4. Fathom

1-16. As engine exhaust passes through the catalytic converter, what chemical compounds are produced by the oxidation of carbon monoxide and hydrocarbons?

1. Nitrates and ketones
2. Hydrogen sulfide and carbon monoxide
3. Carbon dioxide and water
4. Sulfur dioxide and acetones

1-17. Catalytic converters are designed to convert the exhaust gases formed from the combustion of leaded gasoline.

1. True
2. False

1-18. Diesel fuels can retain dirt particles in suspension longer than gasoline because it is heavier and more viscous.

1. True
2. False

1-19. What supervisor approves the use of Jet-A1 and JP–5 as fuel?

1. Maintenance
2. Transportation
3. Project
4. Light shop

1–20. To prevent injector pumps and injector from seizing when jet fuel is used in diesel engines, what ingredient is added to the jet fuel to improve the lubricating qualities?

1. Hydraulic fluid
2. Engine oil
3. Power steering fluid
4. Drive line oil

1-21. The fuel filter operates by passing fuel through a porous material that blocks particles large enough to cause a problem in the fuel system.

1. True
2. False

1-22. What is the purpose of a primary fuel filter on a diesel fuel system?

1. Filters all foreign matter from the diesel fuel
2. Filters minute traces of foreign matter from the diesel fuel
3. Filters the air deposits from diesel fuel
4. Filters the larger foreign matter from the diesel fuel

1-23. A good practice is to drain one gallon of fuel out of the filter into a container or onto a rag during prestart operations.

1. True
2. False

1-24. What is the primary function of the secondary filter?

1. To protect the carburetor
2. To protect the fuel injection pump
3. To protect the fuel transfer pump
4. To protect the fuel supply lines

1-25. What function of the engine creates a partial vacuum in the carburetor throat that allows low-pressure air to rush by the fuel nozzle?

1. The upward compression stroke of the piston
2. The exhaust stroke driven turbocharger
3. The downward intake stroke of the piston
4. The power stroke of the piston

1-26. The primary function of the injection pump is to supply low-pressure fuel for injection.

1. True
2. False

1-27. What is the basic function of injector nozzles?

1. Forms a restriction that causes more fuel and less air to be injected into the combustion chamber of each cylinder
2. Injects fuel into the float chamber of the carburetor
3. Sprays the fuel in atomized form into the combustion chamber of each cylinder
4. Sprays a rich air-to-fuel mixture in the cylinders for the hard job of starting diesel engines

1-28. Glow plugs and injector nozzles are installed in the precombustion chamber of the cylinder head.

1. True
2. False

Learning Objective: Recognize the principles and components of air induction systems.

1-29. Which of the following is NOT the function of a diesel engine air induction system?

1. Cleans the intake air
2. Silences the intake noise
3. Furnishes air for supercharging
4. Controls the fuel and air mixture

1-30. The power that drives the turbine wheel on a turbocharger is generated by what source?

1. Exhaust gases
2. A hot flame
3. Electrical sparks
4. High-pressure air

1-31. Poor combustion is a result of a buildup of dust and dirt in the air cleaner passages that has choked off the air supply.

1. True
2. False

1-32. What person is responsible for cleaning out the collector bowl of a precleaned?

1. The mechanic
2. The washrack custodian
3. The yard boss
4. The operator

1-33. What two stages are dry-element cleaners built to clean?

1. Dry-cleaning and filtering
2. Precleaning and filtering
3. Wet-cleaning and drying
4. Precleaning and discharging

1-34. Which of the following conditions should be looked for when you inspect a dust unloading valve?

1. Cracks
2. Clogging
3. Deterioration
4. All of the above

1-35. What procedure should you use to clean a dusty air filter element?

1. Apply high-pressure air
2. Apply high-pressure water
3. Tap the filter on the heel of your hand
4. Tap the filter on the tire of a vehicle

1-36. What supervisor must approve the washing of any filter elements with water?

1. Transportation
2. Maintenance
3. Light shop
4. 5000 shop

1-37. What happens to the larger dirt particles that are drawn through an oil bath air cleaner?

1. Remains trapped in the filter element
2. Remains trapped in the dust unloader valve
3. Remains trapped in the oil
4. Remains trapped in the dust cup

Learning Objective: Recognize the principles and components an engine lubrication system.

1-38. Which of the following is NOT a function of the engine lubrication system?

1. Absorbs and dissipates heat
2. Seals the piston rings and cylinder walls
3. Provides lubricant to the fuel and air mixture
4. Cleans and flushes moving parts

1-39. From what component is the heat from the engine oil dissipated?

1. The engine sump
2. The radiator
3. The oil jackets
4. The oil expansion tank

1-40. What type of oil filter element fits into a permanent metal container?

1. Precleaned
2. Cartridge
3. Sealed
4. Oil bath

1-41. In what manner does oil pass through a sealed type of oil filter?

1. The oil enters the top of the filter element and passes through the bottom
2. The oil enters the bottom of the filter element and passes through the top
3. The oil enters the bottom center of the filter element and passes through the outside
4. The oil enters the outside of the filter element and passes through to the center

1-42. What type of oil filtering system does NOT filter the oil before it is sent to the engine?

1. Bypass
2. Full flow
3. Partial flow
4. Alternate pass

1-43. Which of the following is NOT a common type of base for hydraulic fluid?

1. Water
2. Petroleum
3. Lithium
4. Synthetic

1-44. Gear oils break down or foam at high temperatures.

1. True
2. False

1-45. Grease lube charts state locations of grease fittings and how often the fitting should be lubricated.

1. True
2. False

1-46. What person has the responsibility for greasing equipment?

1. Yard boss
2. Operator
3. Company clerk
4. Grease rack custodian

Learning Objective: Recognize the principles and components of engine cooling systems.

1-47. The cooling system assists the engine in warming up to its normal operating temperature.

1. True
2. False

1-48. What material is used extensively on air-cooled engines to help dissipate heat?

1. Titanium
2. Plastic
3. Steel
4. Aluminum

1-49. A pump draws coolant from the bottom of a radiator.

1. True
2. False

1-50. What total number of degrees Fahrenheit per pound of coolant does a radiator pressure cap raise the boiling point of the coolant?

1. 12 degrees
2. 9 degrees
3. 3 degrees
4. 6 degrees

1-51. Which of the following conditions, if any, causes the vacuum valve to open on a radiator pressure cap?

1. The cooling system pressure raises above the outside pressure as the engine cools
2. The cooling system pressure drops below the outside pressure as the engine cools
3. The cooling system pressure raises above the outside pressure as the engine warms up
4. None

1-52. Which of the following is NOT a property of water that limits its usefulness as a coolant?

1. Boiling point
2. Freezing point
3. Natural corrosive action on metal
4. Chlorine content in the water

1-53. In the NCF, what is the rule of thumb for fan belt tension?

1. No more the than 1 inch deflection
2. No more than 3/4 inch deflection
3. No more than 1/2 inch deflection
4. No more than 1/4 inch deflection

1-54. The passages of the water jacket are designed to provide what function?

1. Increase the circulation of the coolant
2. Control the circulation of the coolant
3. Control the temperature of the coolant
4. Decrease the temperature of the coolant

1-55. On a cold engine, what component restricts the circulation of coolant?

1. The shutter
2. The overflow tank
3. The water jacket
4. The thermostat

1-56. What component serves as a receptacle for coolant forced out of the radiator overflow pipe?

1. Expansion tank
2. Augmentation tank
3. Overflow tank
4. Contraction tank

1-57. The expansion tank is mounted in series with the lower radiator hose and is used to supply extra room for coolant expansion.

1. True
2. False

1-58. The cooling action on air-cooled engines is based on what simple principle?

1. The surrounding air is cooler than engine heat
2. The surrounding air is cooler than radiator coolant
3. The surrounding air is easier controlled than radiator coolant
4. The engine heat is easier controlled by use of surrounding air

1-59. What component on the cylinder barrel and head provides more cooling area or surfaces and aids in directing air flow?

1. Fan
2. Shroud
3. Fins
4. Baffles

Learning Objective: Recognize the principles and components of transmissions.

1-60. Power from the engine provides the torque required for the transmission to overcome inertia.

1. True
2. False

1-61. What component engages and disengages the engine crankshaft to or from the transmission?

1. Drive shaft
2. Universal joint
3. Clutch
4. Flywheel

1-62. What component of the disc clutch is secured to the engine flywheel?

1. Clutch driven plate
2. Clutch driving plate
3. Clutch release sleeve
4. Clutch release shoe

1-63. Using the clutch as a foot rest creates light spring pressure, resulting with little friction between the two members of the clutch.

1. True
2. False

1-64. At what location is the transmission located within the power train?

1. Between the propeller shaft and rear axle
2. Between the forward rear axle and trunnion axle
3. Between the flywheel and clutch housing
4. Between the clutch housing and propeller shaft

1-65. What device is added to transmissions to equalize the speed of the mating parts before they engage?

1. A countershaft
2. A synchronizer
3. An equalizer
4. A planetary gearset

1-66. What component of the power train allows the operator to apply engine power to the wheels smoothly and gradually?

1. The gearshift lever
2. The propeller shaft assembly
3. The clutch
4. The accelerator pedal

1-67. On a manual transmission, what action should an operator take when waiting at a long traffic light?

1. Depress the clutch pedal until the light turns green
2. Depress the clutch pedal, shift the transmission to neutral, and continue with the clutch depressed until the light turns green.
3. Depress the clutch pedal, shift the transmission to neutral, and release the clutch pedal
4. Depress the clutch pedal, shift the transmission to first gear and continue with the clutch depressed until the light turns green

1-68. During double-clutch shifting, what technique is performed when shifting to a lower gear but not performed when shifting to higher gear speeds?

1. Engine is accelerated when the transmission is in neutral
2. Clutch pedal is fully depressed twice
3. Accelerator pedal is released before depressing the clutch
4. When the clutch is fully depressed, the gearshift lever is placed in the neutral position

1–69. Which of the following factors does NOT affect the performance of an automatic transmission?

1. Throttle position
2. Vehicle speed
3. Engine temperature
4. Position of the shift control lever

1-70. Which of the following components is NOT a part of a torque converter?

1. Generator
2. Pump
3. Turbine
4. Stator

1–71. What part of a torque converter adds its force to the pump by redirecting the oil as it leaves the turbine?

1. The impeller
2. The torus
3. The stator
4. The driving member

1–72. Besides the planet carrier, the planetary gear system includes the sun gear, ring gear, and what other components?

1. Planet pinions
2. Throw-out bearings
3. Star gears
4. Moon pinions

1-73. What component of the planetary gear system has internal teeth?

1. Planet pinion
2. Sun gear
3. Ring gear
4. Planet carrier

1-74. Which of the following is an advantage of the planetary gear system?

1. More teeth make contact to carry the load
2. Gears are always in mesh
3. Ease of shifting
4. Each of the above

1–75. For power to be transmitted through a planetary gear system, which of the following conditions must exist?

1. Engine must deliver power to one of the three members
2. The propeller shaft must be connected to one member
3. One member must be held stationary
4. All of the above

ASSIGNMENT 2

Textbook Assignment: "Power Train" and "Chassis Systems," pages 2-7 through 3-24.

Learning Objective: Recognize the principles and components of automatic and auxiliary transmissions.

2-1. The fluid torque converter is attached to the engine crankshaft and serves as the engine clutch.

1. True
2. False

2-2. When the transmission selection lever is in the drive (D) position, what operation controls the shifting of the transmission from drive to low and back to drive ?

1. Engine speed
2. Propeller shaft rotation speed
3. Rear axle rotation speed
4. Front axle rotation speed

2-3. When placing a transmission selector lever in the drive (D) position, an operator should take what action to avoid premature forward movement of a vehicle?

1. Place wheel chocks in front of the rear wheels
2. Engage the parking brake
3. Maintain pressure on the foot brake
4. Slowly engage the selector lever

2-4. What is the function of an auxiliary transmission?

1. Replaces the main transmission at high temperature operations
2. Replaces the main transmission during fording operations
3. Provides more gear ratios
4. Provides front axle power

2-5. What conditions causes a sprag unit to engage automatically?

1. The rear wheels slip and turn faster than the front wheels
2. The operator shifts to low gear
3. The front wheels slip and turn faster than the rear wheels
4. High--speed operation

2-6. What component of the power train is used to drive auxiliary accessories?

1. Final drive
2. Transfer case
3. Planetary gearset
4. Power takeoff

Learning Objective: Recognize the principles and components of propeller shaft assemblies.

2-7. What assembly provides a path through which power is transmitted from the transmission to the drive axle?

1. Final drive
2. Propeller shaft
3. Differential
4. Dog clutch assembly

2-8. What component sits between and supports two propeller shafts on vehicles with a long wheel base?

1. The center support bearing
2. The auxiliary support transmission
3. The propeller support casing
4. The universal support joint

2-9. What component of the propeller shaft assembly takes care of end play?

1. Leaf springs
2. Universal joints
3. Sprag unit
4. Slip joint

2-10. What component of the propeller shaft assembly functions as a flexible coupling?

1. Center support joint
2. Universal joint
3. Coupling joint
4. Propeller shaft bracket

2-11. Which of the following is NOT a fundamental unit of a universal joint assembly?

1. Journal
2. Flange yoke
3. Fixed or splined sliding yoke
4. Cross carrier

2-12. What problem is the first indication of center support bearing failure?

1. Excessive noise
2. Excessive chassis vibration
3. Clutch slippage
4. Rear-end traction loss

Learning Objective: Recognize the components and functions of final drives and differentials.

2-13. What component changes the direction of power from the propeller shaft to the driving axle?

1. Coupling shaft
2. Converter drive
3. Final drive
4. Transfer case

2-14. What technique should you use to determine the gear ratio on a worm gear final drive?

1. Divide the number of teeth on the worm gear by the number of teeth on the pinion
2. Multiply the number of teeth on the worm gear by the number of teeth on the pinion
3. Count the number of teeth on the worm gear for the number of teeth of the driven gear
4. Count the revolutions of the worm gear for one revolution of the driven gear

2-15. Which of the following gear type of final drives permits a larger speed reduction?

1. Hypoid
2. Worm
3. Spur bevel
4. Spiral bevel

2-16. What component allows one axle shaft to turn at a speed different from that of the other axle shaft?

1. The differential
2. The trunnion
3. The transfer case
4. The power takeoff

2-17. Without a differential, one rear wheel would be forced to skid when turns are made.

1. True
2. False

2-18. On the axle assembly of a truck, what component prevents one wheel from spinning?

1. The propeller shaft lock
2. The countershaft lock
3. The anti-skid lock
4. The differential lock

2-19. Which of the following components supports part of the weight of a vehicle and also drives the wheels connected to it?

1. Trunnion axle
2. Dead axle
3. Live axle
4. Bogie axle

2-20. Which of the following components aids in distributing the load on the rear of the vehicle to the two live axles that it connects?

1. The trunnion axle
2. The final drive
3. The floating axle
4. The torque rods

2-21. Which of the following types of live axles are NOT used in automotive and construction equipment?

1. Semifloating
2. One-half floating
3. Three-quarters floating
4. Full floating

2-22. On a 4 by 4 drive, what component divides the power between the front and rear axle?

1. Power takeoff
2. Differential case
3. Center support housing
4. Transfer case

Learning Objective: Recognize the principle and components of the steering system.

2-23. What part of the steering mechanism connects the front wheels of a vehicle?

1. Steering linkage
2. Steering gear
3. Steering column
4. Steering pitman arm

2-24. The tie rod is usually located behind the front axle. What is its major function?

1. To keep the front and rear wheels in proper alignment
2. To connect both right and left wheels
3. To keep the front wheels in proper alignment
4. To adjust all wheels for alignment

2-25. Which of the following is NOT a type of steering trouble?

1. Hard steering
2. Vehicle wanders
3. Steering kickback
4. Hard or rough ride

2-26. Which of the following components is NOT part of a power steering assembly?

1. Hoses
2. A fluid reservoir
3. A hydraulic pump
4. A leaf clip

2-27. What type of steering is used to turn a whole section of a machine from a vertical hinge?

1. Front and rear
2. Articulated
3. Rear
4. Crab

2-28. What type of steering swings the rear wheels outside of the front-wheel tracks?

1. Front and rear
2. Articulated
3. Rear
4. Four wheel

2-29. What type of steering design reduces rolling resistance in soft ground because one set of tires prepares a path for the other set?

1. Front and rear
2. Articulated
3. Rear
4. Four wheel

2-30. Crab steering moves a machine in a straight line at an angle to its center line.

1. True
2. False

Learning Objective: Recognize the principles and components of suspension systems.

2-31. What component is used to suspend wheels or tracks from a vehicle frame?

1. Drag link
2. Springs
3. Torque rods
4. Shock absorber

2-32. Which of the following problems are symptoms of suspension troubles in vehicle operations?

1. Vehicle wanders
2. Vehicle pulls to one side during normal driving
3. Sway on turns
4. All of the above

2-33. Which of the following components of a multiple leaf spring keeps the springs from separating on the rebound after the spring has been depressed?

1. Spring hanger
2. Leaf clip
3. Spring seat
4. Spring shackle

2-34. Which of the following components of a multiple leaf spring provides a swinging support allowing the spring to straighten out when compressed?

1. Spring hanger
2. Leaf clip
3. Spring seat
4. Spring shackle

2-35. What parts are used to prevent the spring from shifting on track type of tractors?

1. Brackets
2. Shackles
3. U-bolts
4. Hangers

2-36. Coil springs are generally used on which of the following suspension systems?

1. 4 X 4 suspension systems
2. 4 X 6 suspension systems
3. Independent suspension systems
4. All suspension systems

2-37. Rubberized fabric spacers placed at each end of spring coils serve what function?

1. They prevent oil leakage
2. They prevent squeaking
3. They prevent grease leakage
4. They provide a tighter seal between the coil spring and the steering bushing

2-38. Double–acting shock absorbers perform which of the following functions?

1. Prevent metal-to-metal contact when the springs are compressed and absorb torsion from the springs
2. Check spring rebound only
3. Check spring compression and spring rebound
4. Prevent metal-to-metal contact when the springs are compressed and check spring rebound

---

Learning Objective: Recognize the principles and components of tires.

2–39. Abuse and neglect are primary causes of the premature failure of tires.

1. True
2. False

2-40. When operating a vehicle in soft sand, you should take what action, if any?

1. Increase the air pressure in the tires
2. Reduce the tire pressure in the tires
3. Install tire chains
4. None

2-41. What condition prevents a tire from flexing and causes it to be constantly subjected to hard jolts?

1. Overinflated tire
2. Underinflated tire
3. Traveling on a gravel road
4. Traveling in a quarry

2-42. On dual wheels, the valve of the outside dual is placed at what degrees from the valve on the inside dual?

1. 30
2. 90
3. 120
4. 180

2-43. What component of a tire assembly permits air, under pressure, to enter the tire, but prevents it from escaping?

1. Tire ply
2. Tire bead
3. Valve core
4. Valve cap

2-44. What component of a tire assembly prevents dirt and moisture from entering the valve body?

1. The valve cap
2. The valve cup
3. The valve jacket
4. The valve spring washer

2-45. Part of your prestart operation is to ensure all valve stems have valve caps.

1. True
2. False

2-46. Improperly matched tires can cause transfer case and differential failures.

1. True
2. False

2-47. Radial-ply tire can be mixed with bias-ply tires on the same axle.

1. True
2. False

2-48. Which of the following types of tire treads is of a V-design with large spaces between the lugs?

1. Cross-country tread
2. Regular tread
3. Nondirectional tread
4. Directional tread

2-49. On a grader, in what manner are directional tread tires mounted on the dead or steering axle?

1. The point of the V meets the ground first
2. The open part of the V meets the ground first
3. The perpendicular portion of the lugs meet the ground first
4. The rounded shoulder of the lugs meet the ground first

2-50. Which of the following types of tire treads have rounded shoulders and lugs that are placed perpendicular to the center line of the tire?

1. Cross-country tread
2. Regular tread
3. Nondirectional tread
4. Directional tread

2-51. On rock service treads, what is the primary purpose of the narrow voids between the lugs?

1. Provides traction on slippery surfaces
2. Provides flexibility on rocky surfaces
3. Prevents loose rocks from being caught in the lugs
4. Prevents the lugs from filling with mud when working in muddy conditions

---

Learning Objective: Recognize the principles and procedures of tire removal and repair.

2-52. When you raise a vehicle with a jack, always block the wheels on the axle that is being raised with the jack.

1. True
2. False

2-53. When breaking down a tire, you should perform which of the following steps first?

1. Force the tire bead away from the removable side ring
2. Inflate the tire to find the hole
3. Plug the hole in the tire
4. Remove the valve core and deflate the tire completely

2-54. When assembling tires equipped with a removable side ring, you should install the valve stem so that it points towards the removable side ring.

1. True
2. False

2–55. When assembling a tire equipped with a lock ring that does NOT seat properly, you should inflate the tire with how many pounds of air pressure before tapping the lock ring with a mallet?

1. 5 to 10 pounds
2. 15 to 20 pounds
3. 25 to 30 pounds
4. 35 to 40 pounds

2-56. When physically inspecting the inside of a tubeless tire, you should use a rag to protect your hand from injury.

1. True
2. False

2-57. When plugging a tire, you should cut the plug at approximately what distance from the surface?

1. 3/4 inch
2. 1/2 inch
3. 1/4 inch
4. 1/16 inch

2-58. On a tube to be patched, you should buff or roughen the surface at least how many inches around the hole to be patched?

1. 1/2 inch
2. 1 inch
3. 1 1/2 inch
4. 2 inch

2-59. Tire rotation is performed according to the manufacturer’s specifications.

1. True
2. False

2-60. Which of the following personnel supervise the tire shop?

1. Transportation supervisor
2. Maintenance supervisor
3. Projects supervisor
4. Heavy shop supervisor

2-61. Personnel inexperienced in tire repair should only repair tires under direct supervision of an experienced person.

1. True
2. False

Learning Objective: Recognize the principles and components of brake systems.

2-62. A brake system must not only stop a unit of CESE but also must stop it in a smooth, uniform motion.

1. True
2. False

2-63. Which of the following items of a brake system is the operator’s responsibility to check during prestart operations?

1. Brake fluid level
2. Loose connections or parts
3. Leaks
4. Each of the above

2-64. Which of the following types of brakes are classified as individual brakes?

1. External contracting
2. Internal expanding
3. Disc
4. All of the above

2-65. Which of the following types of brakes cannot withstand the high pressure required to produce the friction needed to stop a heavily loaded vehicle?

1. Disc
2. Drum
3. External contracting
4. Internal expanding

2-66. For what system are internal expanding type of brakes exclusively used?

1. Vehicle trailer brakes
2. Vehicle wheel brakes
3. Brakes for controlling speeds of auxiliary drive shafts
4. Winch brakes

2-67. When the breaking action is no longer required of an internal expanding brake system, the brake shoes are returned to their original position by what power source?

1. Vacuum pull
2. Brake fluid pressure
3. Force of retracting springs
4. Force of gravity

2-68. Which type of braking system has a pair of flat pads instead of curved brake shoes?

1. Disc
2. Mechanical
3. Air
4. Electrical

2-69. A mechanical parking brake may be either linked mechanically to the rear wheel brakes or external contracting brake bands located on the drive shaft.

1. True
2. False

2-70. In a hydraulic brake system, what component controls the movement of the brake shoes at each wheel?

1. The wheel cam
2. The wheel cylinder
3. The wheel crank
4. The wheel gear

2-71. On a vehicle brake system, where are the larger wheel cylinders mounted?

1. The rear wheels
2. The front wheels
3. The front and rear left wheels
4. The front and rear right wheels

2–72. On a hydraulic brake system, what component is a reservoir for the brake fluid?

1. Brake fluid storage tank
2. Brake reservoir
3. Master cylinder
4. Slave cylinder

2-73. What action forces the brake fluid back through the flexible hose and tubing to the master cylinder?

1. Retracting springs on the brake shoes
2. Retracting springs on the brake pedal
3. Suction from the master cylinder pump
4. All of the above

2-74. Part of your prestart responsibility is to check the brake fluid level and add clean fluid to maintain the manufacturer’s specifications.

1. True
2. False

2-75. Which of the following braking systems create the frictional surface that gives the braking effect?

1. Lining
2. Drum
3. Disc
4. All of the above

ASSIGNMENT 3

Textbook Assignment: “Chassis Systems,” “Electrical and Hydraulic Systems,”and “Rules of the Road,” pages 3-24 through 5-6.

Learning Objective: Recognize the principles and components of air, air–over–hydraulic, and vacuum brake systems.

3–1. An air brake system uses compressed air to apply the brakes.

1. True
2. False

3–2. In an air brake system, what component pumps air into the storage tanks?

1. The governor
2. The evaporator
3. The air compressor
4. The master cylinder pump

3-3. At what pounds per square inch (psi) of air pressure does a governor stop the compressor from pumping air?

1. 30
2. 60
3. 90
4. 120

3–4. Compressed air usually contains water and compressor oil.

1. True
2. False

3–5. Which of the following components of an air brake system helps reduce the risk of ice in air brake valves?

1. Safety valve
2. Treadle valve
3. Alcohol evaporator
4. Limiting quick–release valve

3-6. Which of the following components of an air brake system protects the tank and the rest of the system from too much air pressure?

1. The safety valve
2. The alcohol evaporator
3. The drain cock
4. The slack adjuster

3-7. When the brake pedal is engaged, air from the air tank flows through what component before flowing through the brake lines connected to the brake chambers?

1. Double–check valve
2. Brake pedal valve
3. Limiting quick-release valve
4. Hand brake valve

3-8. Pressing and releasing the brake pedal unnecessarily may release air out faster from the air tank than the compressor can replace it.

1. True
2. False

3-9. A low air warning device should cut on before the pressure in the air tank(s) drops lower than what pressure?

1. 120 psi
2. 90 psi
3. 60 psi
4. 30 psi

3–10. On a tractor-trailer equipped with air brakes, which of the following components provides the operator control of the trailing load at all times?

1. Master cylinder valve
2. Hand brake valve
3. Trailer protection valve
4. Double-check valve

3-11. Because of the size of the air piston in an air-over-hydraulic brake system, the air pressure is a much greater pressure than the hydraulic pressure that is admitted to the air cylinder.

1. True
2. False

3-12. In a vacuum brake system, what force acts on the rear side of the piston to exert a powerful pull on the rod attached to the piston?

1. Compressed air
2. Mechanical pressure
3. Vacuum
4. Atmospheric pressure

3-13. What type of vacuum braking system contains within one unit, a hydraulically actuated control valve, a vacuum power cylinder, and a hydraulic slave cylinder?

1. Hydrovac
2. air-hydraulic unit
3. electric vacuum unit
4. air pack

Learning Objective: Recognize the principles and components of electrical systems used in automotive and construction equipment.

3-14. Which of the following components is NOT a basic component of an automotive and construction equipment electrical system?

1. A storage battery
2. A charging system
3. A starting circuit
4. An electrostat

3-15. Which of the following components is the heart of the charging circuit?

1. The storage battery
2. The starting circuit
3. The lighting system
4. The gauges

3-16. Battery current is produced by a chemical reaction between the active materials of the plates and what type of acid?

1. Bromic
2. Floric
3. Sulfuric
4. Phosphoric

3-17. You can thoroughly clean a battery by using a stiff brush and what kind of solution?

1. Water and baking soda
2. Water and soap
3. Water and detergent
4. Water and vinegar

3-18. The cell elements of a battery contain two types of lead plates, known as positive and negative.

1. True
2. False

3-19. In what units is the capacity of a battery measured?

1. Cold current amps
2. Circuit cranking voltage
3. Cold cranking amps
4. Continuous cranking voltage

3-20. The charging system recharges the battery and performs what other function?

1. Stores charged amps
2. Generates current during operation
3. Stores charged voltage
4. All of the above

3-21. Dc and ac are the two types of charging systems used on automotive and construction equipment.

1. True
2. False

3-22. What component of the charging system supplies the electrical power and rectifies its current mechanically by using commutator bars and brushes?

1. The generator
2. The alternator
3. The regulator
4. The coil

3-23. Most alternators supply a low current output at low-engine speed.

1. True
2. False

3-24. Which of the following stages is NOT an operating stage of a charging system?

1. The battery supplies all load current during starting
2. The battery supports the generator supply current during peak operations
3. The generator supplies all current and recharges the battery
4. The battery supplies all current for peak operations

3-25. The battery supports the generator or alternator during peak operations.

1. True
2. False

3-26. Which of the following starting circuits is NOT used to increase either the voltage or amperage from a set of batteries?

1. Parallel system
2. Series system
3. Series-parallel system
4. Double-series system

3-27. Hooking up jumper cables from a 24-volt system to a heavy-duty 12–volt system can cause severe battery damage, starter destruction, or even an explosion.

1. True
2. False

Learning Objective: Recognize the principles and components of the lighting system.

3-28. Which of the following is NOT a component of the lighting system?

1. Lamps and bulbs
2. Clearance lights
3. Fuses
4. Stators

3-29. Which of the following personnel is responsible for replacing bad bulbs on equipment?

1. The dispatcher
2. The yard boss
3. The operator
4. The company clerk

3-30. Clearance lights detail which of the following areas of a vehicle?

1. The maximum width only
2. The maximum height only
3. The maximum length only
4. The maximum height and length

3-31. What classification of lights outline the height of a vehicle?

1. Clearance
2. Side marker
3. Identification
4. Taillights

3–32. As viewed from the side, what classification of lights indicate the full-over-all length of a vehicle?

1. Clearance
2. Side marker
3. Identification
4. Taillight

3-33. Which of the following items are used as an additional safety precaution in case lights burn out or are broken?

1. Auxiliary light
2. Spotlight
3. Backup light
4. Reflectors

3-34. A brake light is usually combined with the taillight using what type of bulb?

1. Single-contact, double-filament
2. Double-contact, double-filament
3. Double-contact, florence filled
4. Single-contact, single-filament

3-35. Brakes lights are a safety-required item and must be operational at all times.

1. True
2. False

3-36. Which of the following lights must turn off automatically when a vehicle is moving forward?

1. Brake
2. Parking
3. Backup
4. Side marker

3-37. Which of the following components is the weakest point in an automotive electrical circuit?

1. The bulb
2. The fuse
3. The wiring
4. The electrical connections

Learning Objective: Recognize the principles and components of gauges.

3-38. When the temperature reading on a water temperature gauge starts to rise, you should stop and determine the reason.

1. True
2. False

3-39. Cold water should be added to an overheated engine when it is NOT running.

1. True
2. False

3-40. After an engine is started, what is the rule of thumb for the oil pressure gauge?

1. It should indicate 10 pounds of pressure in 30 seconds
2. It should indicate 30 pounds of pressure in 30 seconds
3. It should indicate 60 pounds of pressure in 30 seconds
4. It should indicate 90 pounds of pressure in 90 seconds

3-41. A low air pressure warning light or buzzer should come on when the air pressure drops below which of the following pressures?

1. 60 psi
2. 90 psi
3. 120 psi
4. 150 psi

3-42. What action should you take if the hydraulic fluid level is normal, but the hydraulic fluid temperature gauge indicates the fluid has exceeded the recommended operating temperature range?

1. Continue to operate at a slow speed
2. Shut down the engine to allow the hydraulic fluid to cool
3. Idle the engine to allow the hydraulic fluid to cool
4. Continue to operate running the engine at full speed

3-43. When operating a piece of equipment, what action should you take if the fuel gauge does NOT indicate any depletion of fuel?

1. Visually check the fuel level from time to time
2. Assume the fuel tank is full
3. Ignore the gauge
4. Park the equipment and notify the mechanic field crew

Learning Objective: Recognize the principles and components of hydraulic systems.

3-44. Which of the following is NOT a component of a hydraulic system?

1. A reservoir
2. A pump
3. Control valves
4. A thermostat

3-45. Which of the following components is the fluid storehouse for the hydraulic system?

1. Hydraulic cylinder
2. Accumulator
3. Reservoir
4. Fluid box

3-46. The baffle plate in the hydraulic fluid reservoir does NOT allow which of the following conditions to occur?

1. The dissipation of air bubbles
2. The settling of contaminants
3. The cooling of the return fluid
4. An excessive formation of air bubbles

3-47. Which of the following components creates the flow of fluid within the hydraulic system?

1. The hydraulic cylinder
2. The control valve
3. The hydraulic pump
4. The strainer

3-48. Hydraulic controls should be operated smoothly to eliminate any jerking motion that causes rapid wear of mechanical parts?

1. True
2. False

3-49. The force created by a hydraulic cylinder is determined by the pressure of the fluid and what other system?

1. The size of the hydraulic hoses
2. The speed of the engine
3. The area of the piston contacted by the fluid
4. The skillful use of control valves

3-50. What type of hydraulic cylinder exerts force in only one direction?

1. Single-acting
2. Double-acting
3. Triple-acting
4. None of the above

3-51. Foreign material exposed on hydraulic rams can damage seals and wiper seals.

1. True
2. False

3-52. When performing pre- and post-operational inspections, you should inspect hydraulic hoses for which of the following conditions?

1. Cracking only
2. Rubbing and cracking only
3. Twisting and rubbing only
4. Twisting, rubbing, and cracking

3-53. Which of the following components performs the work of two shutoff valves and a tube coupler?

1. Pressure relief line
2. Relief valve
3. Quick-disconnect coupler
4. Oil strainer

3-54. What component installed in a hydraulic system is used to absorb shock?

1. Shock absorber
2. Accumulator
3. Piston seal
4. Control valve

3-55. Which of the following components supplies power to a hydraulic motor?

1. Relief valve
2. Accumulator
3. Pump
4. Reservoir

Learning Objective: Recognize the principles of defensive driving.

3-56. Which of the following are common traits displayed by discourteous drivers?

1. Impatience
2. Road hogging
3. Excessive speed
4. All of the above

3–57. As a professional Equipment Operator (EO), you should demonstrate which of the following types of performance when behind the wheel?

1. Aggressive
2. Businesslike
3. Crude
4. Insulting

3-58. Which of the following precautions should you take to avoid rear-ending someone?

1. Have enough room to stop
2. Keep enough distance between you and the vehicle in front of you at stops to see taillights and brake lights
3. Watch vehicles that are two and three vehicles ahead of you
4. All of the above

3-59. As an operator, you are responsible for adjusting your speed to weather and road conditions.

1. True
2. False

3-60. Which of the following items should you NOT do in a vehicle skid?

1. Steer in the direction of the skid
2. Apply light pressure on the accelerator
3. Apply the brakes
4. All of the above

Learning Objective: Recognize the principles of driving under normal conditions.

3-61. Which of the following actions should an operator perform to make a safe turn with a vehicle?

1. Move into the correct turning lane prior to approaching the intersection
2. Signal at least 100 feet before turning
3. Finish the turn in the proper lane
4. All of the above

3–62. The slower the speed of the vehicle ahead, the more road space and time is required to overtake and pass the vehicle.

1. True
2. False

3-63. Passing is permitted if the center line of the road is solid on your side.

1. True
2. False

3–64. When parking in the parking lane on a street. you should park at a maximum of what distance from the curb?

1. 1 foot
2. 2 feet
3. 3 feet
4. 4 feet

3-65. Which of the following personnel are responsible for a backing mishap?

1. The operation chief
2. The transportation supervisor
3. The operator
4. The yard boss

3-66. Which of the following techniques should an operator use to avoid a backing mishap?

1. Blow the horn at least twice before backing
2. Survey the area behind the vehicle before backing
3. Use a backup guide
4. All of the above

3-67. A majority of backing mishaps could have been avoided if operators had used backup guides.

1. True
2. False

3-68. What are the basic parts of an entrance to an expressway?

1. The entrance ramp
2. The acceleration lane
3. The merging lane
4. All of the above

3-69. At what location should you slow down when departing an expressway?

1. Merging lane
2. Deceleration lane
3. Exit lane
4. All of the above

3-70. During a periodic stop, what items should you inspect when giving a vehicle a quick safety inspection?

1. Inspect the conditions of the tires
2. Listen for air leaks
3. Check the load to see if it has shifted
4. All of the above

Learning Objective: Recognize the principles used when driving under hazardous conditions.

3-71. Driving on hard–packed snow is more dangerous than driving on fresh snow.

1. True
2. False

3-72. Which of the following conditions is affected when driving on snow and ice?

1. Visibility
2. Stopping distance
3. Maneuverability
4. All of the above

3-73. You are driving under normal conditions and traveling at 10 miles per hour. Under these conditions, you should allow what number of car lengths of space from the vehicle you are traveling behind?

1. 1
2. 2
3. 3
4. 4

3-74. Which areas of a roadway freeze and remain frozen longer than regular roadway surfaces?

1. Bridges
2. Overpasses
3. Shady areas
4. All of the above

3-75. What action should an operator take if water has entered the brake drums and wet the linings?

1. Drive very fast and slam on the brakes to dry the lining
2. Drive very fast and gently apply the brakes to dry the linings
3. Drive very slow and gently apply the brakes to dry the linings
4. Drive very slow and slam on the brakes to dry the linings

ASSIGNMENT 4

Textbook Assignment: “Rules of the Road” and “Transportation Operations,” pages 5–6 through 6–22.

Learning Objective: (continued) Recognize the principles used when driving under hazardous conditions.

4-1. What is the name of the condition when tires ride on a thin film of water?

1. Slippage
2. Hydroplaning
3. Water skiing
4. Skimming

4-2. Fatigue and sharply reduced vision are the primary causes for the increased danger when driving at night.

1. True
2. False

4-3. You should lower the beams of your headlights within how many feet of an approaching vehicle?

1. 700
2. 600
3. 500
4. 400

4-4. High beams should be used when driving in fog.

1. True
2. False

Learning Objective: Recognize the principles of driving under special conditions.

4-5. When driving in sand, you should take what action to give the tires a wider footprint for traction?

1. Partially inflate the tires
2. Partially deflate the tires
3. Travel at a high speed
4. Travel at a low speed

4-6. Which of the following items should you look for when traveling cross country?

1. Holes
2. Stumps
3. Ditches
4. All of the above

4-7. You must have 8 hours off duty before driving how many hours in a 15 hour period?

1. 6
2. 9
3. 10
4. 12

4-8. What type of force plays a major role in mountain driving?

1. Centrifugal
2. Gravity
3. Inertial
4. Cosmic

4-9. When descending a long steep grade, lower gears allow engine compression and friction to help slow a vehicle.

1. True
2. False

4-10. When operating a large vehicle with a manual transmission, the operator should choose the right gear before starting down a hill.

1. True
2. False

4-11. What is the correct procedure for braking on long downhill grades?

1. Ride the brakes and apply heavy pressure from time to time
2. Ride the brakes and apply medium pressure from time to time
3. Apply fairly light pressure to the brakes to control speed
4. Use the emergency brake only

4-12. What is the purpose of an escape ramp?

1. A ramp used to get off an expressway in a traffic jam
2. A ramp used to stop runaway vehicles
3. A ramp used for emergency vehicles
4. A ramp used to escape the stress of expressway driving

Learning Objective: Recognize the principles and techniques used in vehicle recovery operations.

4-13. Which of the following problems can occur if you use a trial-and-error method during a vehicle recovery operation?

1. The loss of valuable time
2. Damaged equipment
3. Injured personnel
4. All of the above

4-14. Which of the following is a function a wrecker cannot provide during a vehicle recovery operation?

1. Winch
2. Push
3. Tow
4. Lift

4-15. Wrapping a tow cable around a bumper of a mired vehicle will result with a bent bumper.

1. True
2. False

4-16. Which of the following components allows a wrecker to winch a disabled vehicle under conditions where the wrecker cannot be positioned directly behind the vehicle?

1. Level winding device
2. Drum flange
3. Tagline winder
4. Floating sheave

4-17. What can result if you attach a winch cable to only one point on the frame of an overturned truck?

1. Winch cable can snap
2. Rigging gear can bend
3. Frame of truck can bend
4. Propeller shaft can bend

4-18. When towing a vehicle with a tow bar, an operator is required in the vehicle being towed.

1. True
2. False

Learning Objective: Recognize the principles of international signals and road signs.

4-19. The international system used for traffic control devices emphasizes pictures and symbols.

1. True
2. False

4-20. What does the color red indicate on a road sign?

1. Directional guidance
2. Motorist service
3. Stop or a prohibition
4. Scenic guidance

4-21. What does the color blue indicate on a road sign?

1. Directional guidance
2. Motorist service
3. Stop or prohibition
4. Scenic guidance

4-22. What does a diamond-shaped sign signify?

1. Warning
2. Traffic regulation
3. Guidance information
4. Railroad crossing

4-23. What does a pentagon-shaped sign signify?

1. Guidance information
2. Warning
3. Yield
4. Presence of school

4-24. White road markings separate lanes of traffic traveling in different directions.

1. True
2. False

Learning Objective: Recognize the principles, forms, and procedures used in obtaining an operators license.

4-25. Which of the following publications state that all personnel in the Naval Construction Force (NCF) who operate government-owned or rented equipment must have a valid U.S. Government Operator's License in their possession?

1. NAVFAC P-315
2. NAVFAC P-300
3. NRVFAC P-404
4. NAVFAC P-405

4-26. What is the proper authorization to use a piece of equipment?

1. Government Operator's License
2. Valid trip ticket
3. Trainers license
4. Hard card

4-27. What does the acronym MHE mean?

1. Maintenance heavy equipment
2. Mileage highway estimated
3. Military hardware equipment
4. Material-handling equipment

4-28. Which of the following form numbers is used as an application for vehicle operator's identification card?

1. NAVFAC 11240/10
2. NAVFAC 11260/1
3. NAVFAC 9-11240/13
4. NAVFAC 11260/4

4-29. Which of the following form numbers is the Physical Fitness Inquiry for Motor Vehicles Operators?

1. NAVFAC 9-11240/13
2. NAVFAC 11260/4
3. Standard Form 47
4. Standard Form 10

4-30. Which of the following personnel administer the written license test?

1. The operations chief
2. The license examiner
3. The test mechanic
4. The dispatcher

4-31. In the NCF, in what location can you find information particular to a piece of equipment?

1. The equipment glove box
2. The equipment toolbox
3. The dispatch office
4. The technical library

4-32. Which of the following conditions can terminate a performance qualification test?

1. Lack of skill
2. Undue nervousness
3. Inattentiveness
4. All of the above

4-33. Which of the following form numbers is the license required for automotive motor vehicles and materials–handling equipment?

1. NAVFAC 11240/10
2. NAVFAC 11260/1
3. OF-346
4. OF-960

4–34. When does the Operator’s Identification Card expire?

1. At the projected rotation date (PRD) of the operator
2. Three years from the date of issue
3. At 2 year intervals from the date of issue
4. On the birth date of the operator and is valid for 3 years

4–35. Which of the following form numbers is the Construction Equipment Operator License Record?

1. NAVFAC 11260/1
2. NAVFAC 11260/2
3. NAVFAC 11260/3
4. NAVFAC 11260/4

4–36. When does the Construction Equipment Operator License expire?

1. On the birth date of the operator and is valid for 2 years
2. On the date of issue and is valid for 3 years
3. On the projected rotation date (PRD) of the operator
4. At the operator’s end of active obligated service (EAOS) date

---

Learning Objective: Recognize the forms used in dispatch operations.

4–37. Which of the following information is documented on dispatch forms?

1. Miles only
2. Hours only
3. Maintenance performed only
4. Miles, maintenance performed, and hours

4–38. Which of the following personnel have a better opportunity than anyone else to discover defects on equipment before they become serious problems?

1. A mechanic
2. The yard boss
3. An operator
4. The washrack attendant

4-39. Which of the following numbers is a form number for a hard card?

1. NAVFAC 9-11240/13
2. NAVFAC 11240/10
3. NAVFAC 11260/4
4. DD Form 518

4–40. The hard card provides a uniform list of services to be performed on equipment by the operator at which of the following times?

1. Before operation
2. During operation
3. After operation
4. All of the above

4-41. Which of the following form numbers is used for performing prestarts on construction equipment?

1. NAVFAC 11260/1
2. NAVFAC 11260/2
3. NAVFAC 11260/3
4. NAVFAC 11260/4

4-42. Which of the following forms contains a record of an operator's destination, time of departure, time of arrival, and speedometer reading?

1. Standard Form 91
2. DD Form 1970
3. DD Form 518
4. NAVFAC 11260/4

4-43. Which of the following items should be carried in every Navy vehicle at all times?

1. Copies of the SF 91
2. Mishap instructions
3. A pencil
4. All of the above

4-44. What is your first responsibility if you are involved in a mishap?

1. Determine what person was at fault
2. Compute the amount of damage
3. Render aid to the injured
4. Notify your supervisor of the mishap

4-45. Which of the following forms is used to provide any person involved in a mishap with a Navy vehicle the name and organizational assignment of the Navy operator

1. DD Form 518
2. DD Form 1970
3. 1250-1
4. NAVFAC 9-11240/13

Learning Objective: Recognize the functions of the transportation pool.

4-46. What company in an NMCB has the responsibility for the management, maintenance, and administration of transportation, construction, weight-handling and material-handling equipment?

1. Alfa
2. Bravo
3. Charlie
4. Delta

4-47. In a Public Works Department, what officer is responsible for the management of equipment?

1. Maintenance
2. Power plant
3. Transportation
4. Fuel division

4-48. In a NMCB, what person is designated as the equipment officer?

1. Alfa company commander
2. Bravo company commander
3. Charlie company commander
4. Delta company commander

4-49. Which of the following personnel are responsible to the equipment officer for the administration, operations, and operator maintenance of all assigned CESE?

1. Alfa company operations chief
2. Transportation supervisor
3. Senior petty officers
4. All of the above

4-50. Which of the following actions is NOT part of an equipment management program?

1. Conducting prestarts
2. Performing post-operational checks
3. Cleaning weapons
4. Performing operator's maintenance

Learning Objective: Recognize the principles of dispatching.

4-51. Which of the following publications or instructions does NOT set policies and directives for dispatch operations?

1. NAVFAC P-300
2. NAVFAC P-404
3. COMSECOND/COMTHIRDNCBINST 11200.1
4. COMSECOND/COMTHIRDNCBINST 1500.20

4-52. Which of the following positions is the key equipment management position in a unit?

1. Collateral equipage custodian
2. Dispatcher
3. Wash rack attendant
4. Master–at–arms

4–53. In an NMCB, at what location are the spare keys for each piece of equipment maintained?

1. In the dispatch spare key locker
2. In the yard boss spare key locker
3. In the equipment history jacket
4. In the spare key locker maintained at the quarter deck

4-54. Which of the following forms does the dispatcher issue to operators for documenting pre–and post–operational checks on construction, weight–handling, and material–handling equipment?

1. NAVFAC 11260/1
2. NAVFAC 11260/4
3. NAVFAC 11240/13
4. NAVFAC 11240/10

4-55. What component provides a means of listing, by USN number, all the equipment assigned to a unit?

1. Equipment status board
2. Equipment chalkboard
3. Equipment log file
4. Equipment location file

4-56. Which of the following personnel has the responsibility to know the current status and location of every assigned piece of equipment?

1. Company commander
2. Company chief
3. Dispatcher
4. Yard boss

4–57. Using figure 6-13, the 27-00000 registration series is the category for what type of equipment?

1. Spreaders
2. Mixers
3. Asphalt
4. Crushing

4-58. The equipment code is used to establish permanent and positive identification of each piece of equipment.

1. True
2. False

4-59. Which of the following forms provides a ready reference as to the location of all the dispatched vehicles and equipment?

1. NAVFAC 9–11240/13
2. NAVFAC 9-11240/2
3. NAVFAC 11260/2
4. NAVFAC 11260/4

4-60. Which of the following logs is NOT maintained by the dispatcher?

1. Heavy equipment
2. Class D
3. Class C
4. Class B

4-61. Which of the following is NOT a vehicle dispatch category?

1. Class A
2. Class B
3. Class C
4. Class D

4-62. Which of the following COMSECOND/ COMTHIRDNCB instructions requires the Alfa company operations supervisor to review the Dispatcher’s Logs?

1. 4400.3
2. 1500.20
3. 11200.1
4. 5100.1

4-63. NCF dispatcher logs are retained on file for what period of time?

1. 30 days
2. 90 days
3. 180 days
4. 240 days

4-64. Which of the following NAVFAC forms are retained in the trouble reports file?

1. The 11240/6 and 11260/1
2. The 11240/10 and 11260/3
3. The 9-11240/13 and 11260/4
4. The 11240/6 and 11200/41

4-65. On equipment assigned to the NCF, what is the standard interval between PM service inspections?

1. 10 working days
2. 20 working days
3. 30 working days
4. 40 working days

Learning Objective: Recognize the responsibilities of the yard boss.

4-66. Which of the following is NOT an area of responsibility of the yard boss?

1. Equipment yard management
2. Traffic control enforcement
3. Tire shop management
4. Equipment yard maintenance

4-67. Equipment in the equipment pool must be maintained in a standby status and cycled at what time periods?

1. Daily
2. Weekly
3. Monthly
4. Yearly

4-68. Which of the following personnel maintains the equipment cycle log?

1. Equipment cycle custodian
2. Dispatcher
3. Yard boss
4. Shop inspector

4-69. Besides tools, the yard boss should supply which of the following items to support the operator maintenance procedures?

1. Grease guns
2. Valve caps
3. Light bulbs
4. All of the above

4-70. Which of the following personnel has the responsibility of maintaining a hard card log book and issuing hard card numbers?

1. The yard boss
2. The hard card custodian
3. The dispatcher
4. The company chief

Learning Objective: Recognize your responsibilities when performing saltwater operations.

4-71. Exposure to salt water can cause premature damage to brake systems, lubrication fluids, bearings, and overall equipment failure.

1. True
2. False

4–72. To reduce corrosion on an undercarriage, an operator can take what action(s)?

1. Apply water-resistant grease
2. Apply antirust compound
3. Apply a light oil spray
4. All of the above

4–73. To reduce the possibility of damage to the radiator, an operator should enter a body or pool of water as fast as possible?

1. True
2. False

4-74. After operating CESE in or around salt water, the operator should clean and wash it thoroughly with fresh water within what time period?

1. Immediately
2. Within a week
3. Within 2 weeks
4. During the BEEP

4-75. An equipment operator who submerges or buries a piece of equipment should support the recovery, cleaning, and maintenance service of the equipment?

1. True
2. False

ASSIGNMENT 5

Textbook Assignment: “Transportation Operations” and “Tractor-Trailers and Dump Trucks,” pages 6-22 through 7-11.

Learning Objective: Recognize the responsibilities of the collateral equipage and attachment custodian.

5-1. What are the two basic types of collateral equipage?

1. Component and automotive
2. Construction and automotive
3. Component and tactical
4. Construction and tactical

5-2. At what location can a list of types and amounts of component collateral equipage for a single piece of equipment be found?

1. The dispatcher log
2. The history jacket
3. The vehicle data plate
4. The equipment status board

5-3. A spare tire and rim is classified as what type of collateral equipage?

1. Component
2. Automotive
3. Construction
4. Tactical

5-4. What is the number of the form used to document each line item of equipage for each unit of equipment?

1. CB 60
2. 11260/3
3. 11240/6
4. 11200/41

5-5. When is the inventory of mounted or stored collateral equipage for each unit of CESE performed?

1. During operator post-operational maintenance
2. When the equipment is secured
3. On the PM date
4. Each time the equipment leaves the transportation yard

5-6. What is the number of the form used to reorder lost, damaged, or deteriorated collateral equipage?

1. 1250-1
2. 1970
3. 173/3
4. 120–A

5-7. Which of the following personnel has the responsibility for the segregated storage of all attachments and their associated accessories?

1. Yard boss
2. PM runner
3. Attachment custodian
4. Dispatcher

5-8. Attachment storage is maintained so all attachments belonging to one USN number are stored together.

1. True
2. False

5-9. What information can be found on an attachment status board?

1. Attachment code
2. NAVFAC ID number
3. Abbreviated description
4. All of the above

Learning Objective: Recognize the responsibilities of the fuel truck driver and the components and functions of fuel-handling vehicles.

5-10. In an NMCB, which of the following personnel manage the fuel operations?

1. Maintenance supervisor
2. Master–at–arms force supervisor
3. Crane crew supervisor
4. Transportation supervisor

5-11. A poorly managed fuel program results in needless downtime of equipment.

1. True
2. False

5–12. What manual contains the guidelines for maintaining fire extinguishers on the tanker (fuel) truck?

1. NAVFAC P-405
2. EM 385–1-1
3. NAVFAC P-404
4. NAVFAC P-315

5-13. Which of the following characteristics are descriptive of fuel-handling vehicles?

1. Model
2. Size
3. Capacity
4. All of the above

5-14. On a tank truck, what is/are the primary function(s) of the filter/separator?

1. To collect solid contaminants only
2. To separate the water from the fuel only
3. To collect solid contaminants and separate the water from the fuel
4. To ensure fuel is pumped at its maximum pressure and is clean

5-15. What condition results when water or solid contaminants exceed a safe level on a tank truck?

1. The go no-go fuses shuts off the fuel flow
2. The go no-go fuses shuts off the engine pump
3. The fuel filter does not function properly
4. The fuel line clogs and the fuel filters are damaged

5-16. Allowing the engine to run with the transmission engaged and the transfer case shift lever in neutral, without the PTO engaged, causes bearing failure in the transfer case.

1. True
2. False

5-17. Smoking is NOT allowed closer than what distance from a fuel truck?

1. 20 feet
2. 30 feet
3. 40 feet
4. 50 feet

Learning Objective: Recognize the responsibilities and regulations for performing the duties of both bus and taxi driver.

5-18. Besides performing the normal prestart inspections, which of the following components must a bus driver ensure is in good working order?

1. Service brakes
2. Tires and horn
3. Rearview mirror and mirrors
4. All of the above

5-19. What regulation governs the emergency reflectors and fire extinguisher requirements for a bus?

1. NAVFAC P-405
2. ORS-7A
3. TA-01
4. MAC 50-13

5-20. Which of the following personnel has the responsibility for the orderly behavior and safety of all passengers while on board a bus?

1. The highway patrol
2. The bus attendant
3. The master-at-arms
4. The bus driver

5-21. What is the term used to describe the 2-inch line on the floor of a bus which indicates an area where riders can NOT stand?

1. Stand back line
2. Standee line
3. Keep out line
4. Driver's area line

5-22. A bus should stop between 15 and 50 feet before a railroad crossing.

1. True
2. false

5-23. Explosive and flammable material is allowed to be transported in a vehicle carrying passengers

1. True
2. False

5-24. Which of the following is NOT a prohibited practice when transporting personnel on a bus?

1. Fueling with passengers on board under normal conditions
2. Engaging in distracting activities while driving
3. Pushing or towing the bus with passengers under normal conditions
4. Communicating with the dispatcher on a CB radio

5-25. What location normally serves as the base station for taxi service?

1. The quarterdeck
2. The chief's mess
3. The dispatch office
4. The camp club

5-26. Since a taxi is normally smaller than a bus or cargo truck, the taxi driver does NOT have to adhere to the same rules set forth for bus and cargo truck drivers when hauling personnel?

1. True
2. False

Learning Objective: Recognize the principles and techniques used when using time cards.

5-27. In an NMCB, time cards are a labor accounting system used to record what type of data?

1. Man-days
2. Hourly wage
3. Manpower
4. Workdays

5-28. What type of labor directly or indirectly contributes to the accomplishment of the mission of a unit?

1. Overhead
2. Productive
3. Manual
4. Physical

5-29. Man-days expended to support construction operations, but does NOT produce an end product is what type of labor?

1. Manual
2. Direct
3. Indirect
4. Supervisory

5-30. What type of labor does NOT contribute directly or indirectly to the end product?

1. Non-productive
2. Overhead
3. Supervisory
4. Incidental

5-31. In an NMCB, what department has the responsibility of tabulating all of the daily labor distribution reports?

1. Medical
2. Training
3. Operations
4. Construction

Learning Objective: Recognize the principles and responsibilities of embarkation.

5-32. Which of the following units are NOT required to maintain a high state of readiness?

1. NMCB
2. PW
3. PHIBCB
4. CBU

5-33. Detailed procedures for embarkation are outlined in which of the following COMSECOND/COMTHIRDNCB instructions?

1. 11200.1
2. 4400.3
3. 3120.1
4. 5600.1

5-34. What does the acronym MOCC mean?

1. Materials operations control center
2. Mobile outfitted construction corp
3. Main operation communications control
4. Mount-out control center

5-35. The MOCC is under the direction of what officer?

1. Operations
2. Executive
3. Equipment
4. Supply

5-36. The MOCC and what other staff controls all aspects of an NMCB mount-out?

1. Embarkation
2. Security
3. Medical
4. Supply

5-37. In an NMCB, what company is responsible for the preparation of all CESE?

1. Alfa
2. Bravo
3. Charlie
4. Delta

5-38. Procedures for loading CESE on aircraft are outlined in which of the following COMSECOND/COMTHIRDNCB instructions?

1. 11200.1
2. 5100.1
3. 3120.1
4. 5600.1

5-39. When mobile-loaded items are secured to a vehicle by rope, the rope must be what minimum size?

1. One-fourth inch
2. One–half inch
3. Three–fourths inch
4. Five–eighths inch

5–40. What is the maximum amount of fuel the fuel tank on a vehicle can contain if it is to be placed on the ramp of an aircraft?

1. One-fourth full
2. One-half full
3. Three-fourths full
4. Topped-off

5-41. Which of the following personnel notifies the MOCC that a piece of CESE is ready for the weighing and marking station?

1. The yard boss
2. The washrack custodian
3. The dispatcher
4. The maintenance supervisor

5-42. What is the weight limitation for a 463-L pallet?

1. 1,000 pounds
2. 5,000 pounds
3. 8,000 pounds
4. 10,000 pounds

5-43. Before you place any loads on a pallet, how many pieces of dunnage is required to be placed underneath the pallet?

1. Two
2. Three
3. Four
4. Five

5-44. When stacking pallets, you should place dunnage at what height intervals?

1. After every 5 pallets
2. 10 pallets high
3. 15 pallets high
4. 20 pallets high

5-45. During the pallet building process, at what location is the heaviest cargo placed on the pallet?

1. Front left corner
2. Front right corner
3. Rear center
4. Direct center

Learning Objective: Recognize the basic principles of advanced base planning.

5-46. The ABFC System is covered in volume 2 of which of the following NAVFAC publications?

1. P-306
2. P-404
3. P-405
4. P-437

5-47. The overall ABFC System comprises of a preplanned collection of individual functional components.

1. True
2. False

5-48. Which of the following factors can planners for logistics, facilities, and construction identify by using the ABFC System?

1. Equipment
2. Materials
3. Construction effort
4. All of the above

5-49. What part of the P-437 contains data displays for each of the ABFC components and is indexed by code number?

1. One
2. Two
3. Three
4. Four

5-50. What volume of the P–437 contains reproducible engineering drawings?

1. 1
2. 2
3. 3
4. 4

Learning Objective: Recognize the basic principles and functions of tractor–trailers.

5-51. The variety of transmission types used in tractor–trailers requires that operators study the operator’s manual before operating a certain model of tractor–trailer.

1. True
2. False

5-52. Which of the following actions would NOT cause premature failure of drive-line components?

1. Grinding gears while shifting
2. Slipping the clutch
3. Improper downshifting
4. Double clutching

5-53. What person is responsible for the safe loading, securing, and operation of a tractor-trailer?

1. The load master
2. The shot gun rider
3. The operator
4. The yard boss

5-54. What type of trailer is fully enclosed with permanent sides and top?

1. Van
2. Stake
3. Low bed
4. Tilt bed

5-55. What person is responsible for the stake trailer side stakes when they are removed, broken, or lost?

1. The yard boss
2. The operator
3. The attachment custodian
4. The dispatcher

5-56. When placing heavy loads on a tilt-bed trailer, you should place the loads beyond the deck hinge.

1. True
2. False

5-57. What term is often used to identify the detachable gooseneck trailer?

1. Lowboy
2. Tilt top
3. Drop neck
4. Flatbed

5-58. When parked, all 2-ton and above vehicles must be equipped with a set of what type of safety devices?

1. Safety cones
2. Wheel chocks
3. Reflective triangles
4. Warning lights

5-59. When a light bulb does not work during a prestart inspection, you should contact what person to obtain tools and a spare bulb?

1. The dispatcher
2. The collateral equipage custodian
3. The yard boss
4. The toolroom mechanic

5-60. Which of the following is NOT a safety item that should be in the cab of the truck?

1. Three red reflective triangles
2. Fire extinguisher
3. CB radio
4. Accident reporting package

5–61. To perform a hydraulic brake system brake test, you should pump the brakes three times, then apply firm pressure to the pedal for what minimum period of time?

1. 5–seconds
2. 10-seconds
3. 15-seconds
4. 20-seconds

Learning Objective: Recognize the principles, components, and functions of air brakes.

5-62. The air brake system is composed of which of the following combined braking systems?

1. Normal, abnormal, and severe
2. S–cam, wedge, and disc
3. Service, parking, and emergency
4. External, internal, and disc

5-63. What type of brake system applies and releases the brakes when the brakes are used under normal conditions?

1. External
2. Service
3. Parking
4. Emergency

5-64. Overuse of brakes can cause too much heat to be generated, and this condition can result in brake failure.

1. True
2. False

5-65. When you are operating a tractor-trailer, the power springs on the spring brakes are held back by what force?

1. Gravity
2. Mechanical linkage
3. Hydraulic fluid
4. Air pressure

5-66. Tractor and straight truck spring brakes engage when the air pressure drops to what pressure range?

1. 20 to 45 psi
2. 45 to 60 psi
3. 60 to 80 psi
4. 80 to 90 psi

5-67. A diamond shaped, yellow push-pull control knob is used to engage or disengage what component on a tractor?

1. The fifth-wheel lock
2. The front axle PTO shaft
3. The parking brakes
4. The differential lock

5-68. What term is used to describe applying the brakes as hard as possible without locking the wheels?

1. Severe braking
2. Controlled braking
3. Panic braking
4. Stab braking

5-69. You should NOT use the trailer hand valve because of the danger of making the trailer skid.

1. True
2. False

5-70. What condition(s) result when the tractor protection valve closes?

1. Air is kept from escaping from the tractor only
2. The air compressor is shut down only
3. Air from the tractor emergency line is shut off and the air compressor is activated
4. Air from the trailer emergency line is shut off and air is kept from escaping from the tractor

5-71. What is the name of the line that carries air to the trailer and is controlled by the foot valve or trailer hand brake?

1. Service
2. Emergency
3. Drive
4. Electrical

5-72. As pressure increases in the service line, what valve opens and sends air pressure from the trailer air tanks to the trailer brake chambers?

1. The release
2. The protector
3. The relay
4. The jet

5-73. What is the function of the emergency line?

1. Sends air to the relay valve only
2. Supplies air to the trailer air tanks only
3. Sends air to the relay valve and controls the emergency brakes on combination vehicles
4. Supplies air to the trailer air tanks and controls the emergency brakes on combination vehicles

5-74. What is the name of the rubber seals that are on the glad hand?

1. Rubber washer
2. Rubber grommet
3. Rubber gasket
4. Rubber mate

5-75. The emergency line connection is easy to identify because it is red in color.

1. True
2. False

ASSIGNMENT 6

Textbook Assignment: "Tractor-Trailers and Dump Trucks," and "Forklifts, Front-End Loaders, Excavators, and Ditchers," pages 7-13 through 9-10.

Learning Objective: Recognize the principles and functions of tractor-trailer operations.

6-1. Which of the following personnel manages the Naval Construction Force (NCF) transportation operations?

1. Maintenance supervisor
2. Projects supervisor
3. Transportation supervisor
4. Embarkation supervisor

6-2. Which of the following is NOT a required trait to be an operator of a tractor-trailer?

1. Mature
2. Strong
3. Reliable
4. Experienced

6-3. A tractor and trailer are separate units joined together by which of the following assemblies?

1. Gooseneck
2. Universal joint
3. Mounting plate
4. Fifth wheel

6-4. On a tractor-trailer unit, the kingpin is at what location?

1. Upper fifth wheel
2. Upper mounting plate
3. Lower universal joint
4. Lower gooseneck

6-5. NCF assigned trailers normally have two electrical connections adaptable for what electrical voltages?

1. 6 or 12
2. 12 or 24
3. 120 or 240
4. 260 or 360

6-6. When operating a tractor-trailer, you use what two factors as a guide to determine when to shift the transmission?

1. Engine rpm and road speed
2. Engine and transmission temperatures
3. Transmission pressure and road speed
4. Engine noise and water temperature

6-7. On a tractor-trailer equipped with an automatic transmission, what transmission range provides greater braking power when going down grades?

1. High
2. Medium
3. Neutral
4. LOW

6-8. Which of the following is the most recommended method for backing a tractor-trailer?

1. Blind side
2. Sight side
3. Back side
4. Front side

6-9. When pulled off the side of a two-lane road or divided highway, the first set of reflective triangles must be placed a total of how many feet from the front and rear corners of a tractor-trailer?

1. 10
2. 20
3. 30
4. 40

6-10. What is the rule of thumb for following distance when operating a tractor-trailer under 40 mph?

1. 1 second for each 10 feet of vehicle length
2. 5 seconds for each 25 feet of vehicle length
3. 10 seconds for each 35 feet of vehicle length
4. 15 seconds for each 40 feet of vehicle length

Learning Objective: Recognize the terms and procedures used when loading and securing cargo.

6-11. When you are hauling cargo, it takes less time to tie down a load than it takes to report the reason a load fell off a trailer.

1. True
2. false

6-12. Which of the following terms means the weight of a power unit including the trailer(s) and cargo?

1. Gross vehicle weight
2. Gross combination weight
3. Gross vehicle weight rating
4. Curb weight

6-13. Which of the following terms means the total weight of an empty truck with the fuel tank, cooling system, and crankcase filled?

1. Gross vehicle weight
2. Gross combination weight
3. Gross vehicle weight rating
4. Curb weight

6-14. During what operating condition is it recommended that the payload of a truck be equal to 80 percent of the maximum permissible payload?

1. Ideal
2. Moderate
3. Intensifying
4. Severe

6-15. Cargo distribution has a definite bearing on which of the following parts of a vehicle?

1. Tires
2. Axles
3. Frame
4. All of the above

6-16. Axle weights prevent the overloading of bridges and roadways.

1. True
2. False

6-17. The center of the payload on a tractor–trailer unit is at what location?

1. Over the rear tires of the tractor
2. Over the rear tires of the trailer
3. Roughly the center of the trailer
4. Directly behind the fifth wheel

6-18. When loading crawler machines onto a trailer, you must move very fast at the top of the ramp to prevent a slow jarring fall when the machine is past the balance point.

1. True
2. False

6–19. What is the ideal slope for a loading ramp constructed out of dirt?

1. 1 to 1
2. 2 to 1
3. 3 to 1
4. 4 to 1

6–20. A loading ramp or dock should NOT be used to unload equipment from a tilt–bed trailer.

1. True
2. False

6-21. Which of the following are NOT a high point in a roadway that can affect the low ground clearance of a detachable gooseneck trailer?

1. Railroad tracks
2. Road reflector
3. Speed bump
4. Dips

6-22. You should inspect cargo and securing devices within how many miles after beginning a trip?

1. 25
2. 50
3. 75
4. 100

6-23. Aggregate spilling from a dump truck is the responsibility of the operator and is a hazard to automotive windshields?

1. True
2. False

6-24. What weight rating must an assembly of tie-downs have when you are hauling a grader that weighs 35,000 pounds?

1. 35,000 pounds
2. 48,000 pounds
3. 52,500 pounds
4. 64,300 pounds

6-25. Who has the responsibility for setting the weight, height, and width limitations of cargo loads?

1. Each city
2. Each county
3. Each state
4. Congress

Learning Objective: Recognize the basic characteristics and operations of dump trucks.

6-26. What component raises and lowers the dump bed on a dump truck?

1. Hydraulic hoist assembly
2. Manual hoist assembly
3. Cable drawn lift assembly
4. Electrical raise assembly

6-27. In what direction should you position the front of the dump truck when performing dumping operations on an incline?

1. Parallel to the incline
2. Diagonal to the incline
3. Upward with the incline
4. Downward away from the incline

6-28. What step should an operator perform if a load piles up and blocks the tailgate during dumping operations with a dump truck?

1. Manually shovel the material away
2. Place the truck in low gear and drive forward until clear
3. Place the truck in reverse and back up to push the material clear
4. Wash the material clear with a fire hose

6-29. To spread a load with a dump truck, the operator should shift the truck in high gear and drive forward as fast as possible while dumping.

1. True
2. False

6-30. What steps should an operator perform to prepare a dump truck to haul large rocks in a dump bed that is NOT designed for this purpose?

1. Line the dump bed with a mattress
2. Line the dump bed with planking
3. Line the dump bed with several coats of paint
4. Line the dump bed with an asphalt mix

6-31. What steps should an operator perform to prepare a dump truck to haul asphalt?

1. Coat the bed with gasoline
2. Heat the bed with a torch
3. Coat the bed with diesel
4. Heat the bed with hot water

Learning Objective: Recognize the principles, components, and attachments used on forklifts.

6-32. Operations that require raising, lowering, or moving an item is classified as what type of operation?

1. Weight handing
2. Materials handling
3. Storage movement
4. Construction movement

6-33. Which of the following components on a warehouse forklift permits loads to be lifted beyond the height of the collapsed mast?

1. Fork extension
2. Boom extension
3. Telescopic mast
4. Counterweight

6-34. What term is used to describe the height the forks can raise before the inner slides move upward from the mast to increase the overall height?

1. Immediate lift
2. Free lift
3. Chain lift
4. Max lift

6-35. The 4K forklift is capable of fording streams or pools of water of what depth?

1. 12 inches
2. 24 inches
3. 30 inches
4. 36 inches

6-36. The safety pin on the 4K forklift prevents the forklift from performing which of the following operations?

1. Lifting
2. Oscillating
3. Traveling
4. Articulating

6-37. On the 4K forklift, what is the function of the axle disconnect lever?

1. Disconnects transmission output to the front axle only
2. Disconnects transmission output to the rear axle only
3. Disconnects front and rear axle steering
4. Disconnects transmission output to the front and rear axle

6-38. On the 4K forklift, the steering bypass valve allows the front chassis to pivot freely on the rear chassis when towing the forklift.

1. True
2. False

6-39. The safety pin must be installed when the 4K forklift is being towed.

1. True
2. False

6-40. What is the maximum travel speed when towing the 4K forklift?

1. 55 mph
2. 45 mph
3. 35 mph
4. 25 mph

6-41. What component on the 6K RT forklift allows the rotation of the forklift frame about its longitudinal axis?

1. Articulating hydraulic cylinder
2. Longitudinal hydraulic cylinder
3. Oscillating hydraulic cylinder
4. Directional hydraulic cylinder

6-42. The inching pedal on the lift–king forklift should be used as a clutch pedal during normal operations.

1. True
2. False

6-43. The lift interrupt device on the lift–king forklift prevents the forks from being raised above what maximum height?

1. 43 inches
2. 60 inches
3. 96 inches
4. 120 inches

6-44. What is the purpose of sealing the exhaust pipe when transporting the lift-king forklift on a tractor–trailer?

1. Prevents rainwater from entering the engine
2. Prevents insects from entering the engine
3. Prevents autorotation of the turbocharger turbine
4. Prevents vandals from sabotaging the engine

6-45. A forklift attachment may reduce the capacity of the forklift by changing the center of gravity of the load.

1. True
2. False

6-46. Which of the following forklift attachments is used when handling Air Force 463–L pallets?

1. Crane boom
2. Pallet handling
3. Drum handling
4. Fork extension

Learning Objective: Recognize the principles of forklift operations.

6-47. What simple principle does a forklift operate on?

1. Leverage
2. Fulcrum
3. Elevation
4. Lifting

6-48. What part of the forklift performs as the fulcrum?

1. The counterweight
2. The drive axle
3. The hoist cylinder
4. The forks

6-49. To develop the skills required for safe and efficient forklift operations, you must have an understanding of which of the following characteristic of a forklift?

1. Makeup
2. Capabilities
3. Limitations
4. All of the above

6-50. On most forklifts, the center of balance (C/B) is at what location?

1. Above the rear axle
2. Above the front axle
3. Under the operator’s seat
4. Under the engine compartment

6-51. When carrying a load with a forklift, you should always carry the load as high as possible to obtain maximum stability and vision.

1. True
2. False

6-52. A forklift can safely lift and carry no more than its rated capacity.

1. True
2. False

6-53. You should operate a forklift in reverse when a bulky load obstructs your vision.

1. True
2. False

6-54. When carrying a load with a forklift, you should ascend or descend inclines in what manner?

1. With the load pointing downgrade
2. With the load pointing upgrade
3. With the load parallel to the grade
4. With the load diagonal to the grade

6-55. Which of the following is NOT a special condition that would require you to reduce the load weight a forklift is lifting?

1. Weak flooring
2. Uneven terrain
3. Compacted surfaces
4. Loads with a high center of gravity

6-56. When, if ever, should you add additional weights to the counterweights of materials-handling equipment to increase the stability or lifting capacity of the equipment?

1. During weight tests
2. During maximum lifts
3. When traveling down inclines
4. Never

6-57. The operator should sound the horn as a warning when traveling with a forklift down narrow aisles and around blind corners.

1. True
2. False

Learning Objective: Recognize the principles and attachments of front-end loaders.

6-58. A front-end loader (FEL) can NOT be equipped to operate the same as which of the following types of equipment?

1. Dozer
2. Scraper
3. Roller
4. Forklift

6-59. At what percentage of a front slope can a rubber-tired FEL operate?

1. 10 percent
2. 20 percent
3. 30 percent
4. 40 percent

6-60. At what percentage of a front slope can a crawler-mounted FEL operate?

1. 30 percent
2. 40 percent
3. 50 percent
4. 60 percent

6-61. Which of the following components of a crawler-mounted FEL permit it to work on firm ground, causing little damage to the surface?

1. Rubber tires
2. Semi-grouser shoes
3. Leaf spring suspension
4. Support rollers

6-62. Loaders used in the NCF are normally procured with which of the following attachments?

1. Bucket
2. Forklift
3. Backhoe
4. All of the above

6-63. What type of loader bucket is more versatile because it has a two-piece construction?

1. Perforated
2. General purpose
3. Multipurpose
4. Solid plate

6-64. A multipurpose bucket can be used to perform the same operations as which of the following types of equipment?

1. Clamshell
2. Dozer
3. Scraper
4. All of the above

6-65. Techniques of operation and safety rules for forklifts must be followed when operating a loader with a forklift attachment.

1. True
2. False

Learning Objective: Recognize the techniques of front-end loader operation.

6-66. Which of the following problems is caused by spinning the tires while loading with a rubber-tired FEL?

1. Ruts in working area
2. Wear and tear on the machine
3. Lost production
4. All of the above

6-67. Which of the following results is produced when you cross a ditch with a loader at an angle?

1. Slows the fall
2. Lessens the danger of upsetting the loader
3. Reduces the jolt of the fall
4. All of the above

6-68. An unsafe condition exists on a construction project. What person has the responsibility to give an emergency stop hand signal?

1. The project supervisor
2. The equipment signalman
3. Any person in the vicinity
4. The project crew leader

6-69. What is the function of the 515 B series dresser automatic bucket leveler?

1. Automatically raises the bucket when fully loaded
2. Automatically positions the bucket in a horizontal position
3. Automatically positions the bucket in a vertical position
4. Automatically dumps the bucket when positioned over a dump truck

6-70. Most front-end loaders are equipped with a total of how many bucket control lever positions?

1. Four
2. Two
3. Six
4. Eight

6-71. When the multipurpose bucket is set up for scraper operations, the more the clamshell is closed the deeper a cut can be made.

1. True
2. False

6-72. When using the multipurpose bucket as a dozer blade, you adjust the amount of cut made by the dozer blade by taking what action?

1. Raising and lowering the blade
2. Opening and closing the clamshell
3. Adjusting the pitch of the blade
4. Putting the bucket control lever in float

Learning Objective: Recognize the principles of loader operations.

6-73. When loading a dump truck from a bank or stockpile, you should position the dump truck at what angle from the stockpile?

1. Between 10° to 20°
2. Between 30° to 45°
3. Between 50° to 75°
4. Between 80° to 90°

6-74. You should load a dump truck upwind to prevent dirt and dust from blowing back into your face?

1. True
2. False

6-75. When transporting material with a rubber-tired FEL, you should give the bucket the same ground clearance as provided by which of the following components?

1. The final drive breather
2. The transmission
3. The loader axle
4. The center support bearing

ASSIGNMENT 7

Textbook Assignment: "Front-End Loaders, Excavators, and Ditchers" and "Graders and Scrapers," pages 9-11 through 10–19.

Learning Objective: (continued) Recognize the principles of loader operations.

7-1. Which of the following loader operational techniques provides greater force and penetration to loosen large rocks?

1. Squeezing the tip of the rocks with the clamshell
2. Digging under the rocks with the bucket
3. Dozing under the rocks with the blade
4. Back dragging the rocks with the clamshell

7-2. What action should a loader operator take when loading large rocks into dump trucks?

1. Drop small rocks in the dump bed to cushion the large rocks
2. Gently load the large rocks from the lowest possible height
3. Place a load of dirt or sand in the dump bed to cushion the large rocks
4. Load in the center of the dump bed with the clamshell

7–3. Improper loading techniques with a multipurpose bucket can cause unnecessary damage to the bucket.

1. True
2. False

Learning Objective: Recognize the principles of backhoe operations.

7-4. The digging depth of a backhoe attachment is limited by what components?

1. Bucket size and length of dipper stick
2. Length of boom and dipper stick
3. Bucket size and length of boom
4. Backhoe coupling and positive hydraulic pressure

7-5. What type of fitting allows the easy attachment of the backhoe to the loader?

1. Quick disconnect hydraulic fittings
2. Manual connect hydraulic fittings
3. Forced driven hydraulic fittings
4. Screw pin hydraulic fittings

7–6. After the backhoe is attached to the 515 dresser loader, the operator should raise the boom arm until the boom arm pivot point is approximately how many inches from the ground?

1. 6
2. 15
3. 20
4. 36

7–7. Which of the following problems results from setting the engine throttle in excess of that set for backhoe operations?

1. Creates excessive engine temperatures
2. Creates excessive digging pressure
3. Creates excessive hydraulic temperatures
4. Creates excessive boom swing

7-8. What action can an operator perform that signals a backhoe is warmed and ready for operation?

1. Check the hydraulic oil temperature
2. Check the engine oil temperature
3. Feel the backhoe hydraulic hoses for warmth
4. Feel the backhoe hydraulic rams for warmth

Learning Objective: Recognize the principles and components of the loader backhoe.

7-9. The loader backhoe tractor is equipped with a bucket of what size?

1. 1.3 cubic yards
2. 2.0 cubic yards
3. 2.5 cubic yards
4. 3.0 cubic yards

7-10. Which of the following components on the loader backhoe tractor provides equal power to both rear wheels?

1. Limited slip transmission
2. Positive traction transaxle
3. Differential lock
4. Multi–speed final drive

7-11. Disengaging the differential lock when the loader is turning or when one wheel is rotating faster than the other wheel can cause damage to the transaxle.

1. True
2. False

7–12. What is the first step an operator should perform when preparing to operate the backhoe attachment?

1. Rotate the bucket to the dump position
2. Remove the swing lockpin
3. Extend the length of the boom
4. Lower the stabilizers

7-13. The backhoe bucket can be adjusted to a total of how many digging positions?

1. One
2. Two
3. Three
4. Four

7-14. What condition results when an operator of a backhoe attempts to excavate a load that is too large?

1. Positive digging halt
2. Control lever shutdown
3. Hydraulic stall
4. Excavation refusal

Learning Objective: Recognize the principles and components of excavators.

7-15. Which of the following excavator mountings are used in the Naval Construction Force (NCF)?

1. Track
2. Truck carrier
3. Self-propelled wheel
4. All of the above

7-16. Which of the following is NOT a structural component of an excavator?

1. Revolving unit
2. Travel base
3. Winch assembly
4. Attachment

7-17. Which of the following structural components carries the engine, pumps, attachments, controls, and the operator’s cab?

1. The revolving unit
2. The travel base
3. The winch assembly
4. The primary attachment

7-18. Which of the following mounting is the most commonly used excavator travel unit?

1. Track
2. Truck
3. Self-propelled wheel
4. Train

7-19. "A massive frame that includes the turntable and the dead axles or cross members that transmit weight to the track frames." This statement is a description of what component of an excavator?

1. The superstructure
2. The attachment assembly
3. The carbody
4. The counterweight

7-20. What is the rotation work range of a truck-mounted excavator in degrees?

1. 360°
2. 270°
3. 180°
4. 90°

7-21. Which of the following advantages does a truck-mounted excavator have over a track-mounted type?

1. Stability
2. 360° rotation work range
3. Low ground-bearing pressure
4. Rapid mobility

7-22. The front axle oscillation lock levers on the self-propelled wheel-mounted excavator are used to help stabilize the excavator during which of the following operations?

1. Travel
2. Working over the side
3. Loading on a low-bed trailer
4. Beach operations

7-23. Before traveling with an excavator, you should check the travel route for which of the following limits?

1. Weight
2. Height
3. Width
4. All of the above

7-24. You should stop traveling with the self-propelled wheel-mounted excavator after 2 hours of highway travel to allow the tires to cool for what period of time?

1. 1/2 hour
2. 1 hour
3. 2 hours
4. 3 hours

Learning Objective: Recognize the principles and components of excavator attachments.

7-25. Which of the following is NOT a structural member of a hydraulic excavator attachment?

1. Boom
2. Bridle assembly
3. Dipper stick
4. Bucket

7-26. An excavator boom that is concave toward the ground allows for which of the following operations?

1. Space to pull the bucket closer to the excavator
2. Permits deeper digging
3. Enables the operator to see past it when raised
4. All of the above

7-27. The bottom adjustment hole on the boom for connecting the boom cylinder rod eye provides what maximum operation?

1. Dump height
2. Digging depth
3. Reach
4. 360° rotation work range

7-28. What term is used to describe the operation of the bucket digging toward the excavator?

1. Excavation
2. Positive digging operation
3. Crowding
4. Reaching

7-29. Which of the following components supplies the required around-a-curve reach preventing the cylinder from being pulled in against the dipper stick when extended?

1. Dump arms
2. Boom connecting pins
3. Swing guide
4. Centralizer

7-30. A bucket is usually slightly wider at the rear of the bucket to reduce friction.

1. True
2. False

Learning Objective: Recognize the principles of backhoe digging operations.

7-31. Before performing any type of excavation, an operator should check or obtain what type of permit?

1. Landscaping
2. Operators
3. Digging
4. Environmental

7-32. What item determines how much material can be excavated during each digging cycle?

1. The engine rpm
2. Operator expertise
3. The length of the dipper stick
4. The type of material

7-33. What grade stakes should an operator NOT disturb because they are used as a reference when excavating a ditch?

1. Offset
2. Centerline
3. Shoulder
4. Slope

7-34. It is better to excavate 1 to 2 inches below grade than not excavate deep enough.

1. True
2. False

7-35. Which of the following situations can occur if an operator improperly plans an excavation?

1. Trap the machine
2. Machine cannot be positioned to complete job
3. Hand digging required to complete job
4. All of the above

7-36. A digging sequence should be planned to allow a maximum amount of spoil to be excavated before the machine is moved to the next position.

1. True
2. False

7-37. During an excavation, an operator should ensure what objective is reached before repositioning the backhoe?

1. Grade (depth) of excavation
2. Length of excavated material
3. Height of excavated material
4. Maximum compaction of excavation

Learning Objective: Recognize the principles of operations and components of ditchers.

7-38. What term is used to describe a temporary cut made in the earth for underground utilities?

1. An excavation
2. A ditch
3. A trench
4. A gully

7-39. Bucket teeth should be reversed or replaced when the teeth wear down to approximately what length?

1. 1/2 inich
2. 1 inch
3. 1 1/2 inches
4. 2 inches

7-40. Which of the following ditchers is most commonly used in the NCF?

1. Wheel
2. Ladder
3. Chain
4. Blade

7-41. Before starting any ditcher excavation project, the operator must ensure what type of permit that covers the area to be excavated is attained?

1. Excavation
2. Ditching
3. Digging
4. Trenching

7-42. The boom on the ladder ditcher can be brought no closer than what maximum number of degrees to the vertical?

1. 15°
2. 25°
3. 35°
4. 45°

7-43. What component on a ladder ditcher is used for the major job of cleaning out and smoothing the ditch after the teeth have cut the material?

1. Bucket teeth
2. Crumber
3. Stinger
4. Conveyor

7-44. The chain teeth on a chain ditcher is used to cut and lift the cut material to the surface.

1. True
2. False

7-45. Which of the following ditchers dig faster in dense material and is preferred for cross-country digging where speed is needed?

1. Wheel
2. Ladder
3. Chain
4. Blade

Learning Objective: Recognize the principles of graders and grader components.

7-46. What is the primary purpose of a grader?

1. Dig, load, and dump material with the blade in low elevations
2. Cut and move material with the blade for final shaping and finishing
3. Rip and cut extremely hard material with the blade for crusher operations
4. Rip and excavate in-place aggregates with the blade and ripper attachment

7-47. What component of a grader permits passing through depressions or ditches one wheel at a time?

1. Tandem drive
2. Articulated frame
3. Oscillating frame
4. Longitudinal drive

7-48. Which of the following types of grader steering helps compensate for side drift when turning windrows, keeps tandems on firm footing when clearing ditches, and increases stability on side slope work?

1. Four-wheel
2. Front-wheel
3. Crab
4. Rear-wheel

7-49. Articulating the grader sharply can position the rear tires to run into the blade when the blade is angled in an acute position.

1. True
2. False

7-50. Which of the following parts of a front axle on a grader allows the front wheels to lean as well as turn?

1. The upper section
2. The intermediate section
3. The lower section
4. The center section

7-51. During spreading operations, what term is used to describe the leading edge of a grader blade?

1. The heel
2. The finger
3. The arch
4. The toe

7-52. What term is used to describe the grader rotatable ring?

1. Side shift guide
2. Drawbar
3. Circle
4. Scarifier

7-53. What component carries the full--horizontal load on the grader blade?

1. Side shift guide
2. Drawbar
3. Circle
4. Scarifier

7-54. What component of the grader is used to break up material too compacted to be penetrated by the blade?

1. Circle knees
2. Drawbar
3. Side shift breaker
4. Scarifier

Learning Objective: Recognize the principles of grader operations.

7-55. The extensive skill required to perform as an effective grader operator is only gained through practice and on-the-job experience.

1. True
2. False

7-56. An operator of a grader counteracts a pulling force to the right on the front of the grader by performing what operation?

1. Leaning the top of the front wheels to the right
2. Leaning the top of the front wheels to the left
3. Turning the steering wheel to the right
4. Turning the steering wheel to the left

7-57. When you are grading on a project, it is more efficient to turn the grader around than grade in reverse or back the grader when the distance of the pass exceeds how many feet?

1. 400
2. 600
3. 800
4. 1,000

7-58. Which direction is a blade pitch adjusted to achieve a greater cutting action?

1. Upright
2. Backward
3. Slight forward
4. Fully forward

7-59. The proper moisture content supports the binding of material required for compaction.

1. True
2. False

7-60. What is the first cut performed when cutting a ditch?

1. Ditch cut
2. Shoulder pickup
3. Marking cut
4. Spreading pass

7-61. At what degree angle is the grader blade positioned to perform an efficient ditch cut?

1. 90°
2. 75°
3. 65°
4. 45°

7-62. What term is used to describe the operation that spreads material away from the ditching operations and toward the middle of the road?

1. Ditch cut
2. Shoulder pickup
3. Spreading pass
4. Crowning

7-63. When you are cutting the backslope of a ditch, the circle and blade is set in a position that ensures the cut material will flow in what direction?

1. Outside the right rear tandem
2. Outside the right front tire
3. Inside the right rear tandem
4. Inside the right front tire

7-64. What term is used to describe the slope of a road from the center line of the road toward the shoulders?

1. Foreslope
2. Backslope
3. Travelway
4. Crown

7-65. At what direction should an operator position the front wheels of a grader when performing high bank cuts?

1. Lean the top of the wheels towards the bank
2. Lean the top of the wheels away from the bank
3. Steer the wheels towards the bank
4. Steer the wheels away from the bank

7-66. When performing blade mix operations, the operator should pitch the blade slightly forward and angled at what degree angle?

1. 10°
2. 20°
3. 30°
4. 40°

7-67. An operator should raise the grader blade to what height from the surface when performing snow removal operations?

1. 1/2 to 1 inch
2. 1 1/2 to 2 inches
3. 2 1/2 to 3 inches
4. 3 1/2 to 4 inches

7-68. What term is used to describe the operation of a fine cut or fill of a surface to achieve the final desired elevation?

1. Finish grading
2. Elevation achieving
3. Blue topping
4. Cat skinning

7-69. What grader efficiency factor percentage is used for computing grader time estimates?

1. 90 percent
2. 80 percent
3. 70 percent
4. 60 percent

Learning Objective: Recognize the principles and components of scrapers.

7-70. What term is used to describe the type of dozer that pushes a scraper through heavy or consolidated material?

1. Drive cat
2. Push cat
3. Thrust cat
4. Shove cat

7-71. Which of the following types of equipment can be used to load scrapers?

1. Crane clamshell
2. Conveyor
3. Front-end loader
4. All of the above

7-72. In what manner is material loaded in a paddle wheel scraper?

1. Bottom loaded by a paddle wheel elevator
2. Top loaded by a paddle wheel elevator
3. Force loaded from the cutting edges
4. Bottom loaded by screw augers

7-73. What component on a scraper permits the tractor and scraper to tip independently from side to side?

1. Vertical kingpin swivel
2. Horizontal gooseneck
3. Longitudinal horizontal hinge
4. Vertical tip hinge

7-74. On a three-piece cutting edge, what term is used to identify the center cutting edge?

1. Stinger
2. Point cutter
3. Scraper
4. Intermediate bit

7-75. The bottom front sides of a scraper bowl usually have bolt-on wear plates that are known by what term?

1. End bits
2. Wear bits
3. Side cutters
4. End cutters

ASSIGNMENT 8

Textbook Assignment: “Graders and Scrapers” and “Dozers and Rollers,” pages 10–19 through 11-29.

Learning Objective: (continued) Recognize the principles and components of scrapers.

8-1. Which of the following scraper components forms the rear wall of the bowl?

1. The stinger
2. The apron
3. The ejector
4. The paddle wheel

8-2. Which of the following are the basic control levers on a scraper?

1. The bowl
2. The apron control
3. The ejector
4. All of the above

Learning Objective: Recognize the principles of scraper operations.

8-3. When you are operating a scraper, what component must be properly engaged to obtain maximum engine power output?

1. Transmission gear ratio
2. Differential lock
3. Bogie drive shift lever
4. Transfer case sprag unit

8–4. Improper down shifting overspeeds the transmission and engine usually resulting in premature wear.

1. True
2. False

8-5. Downhill scraper speed should NOT exceed what maximum speed in miles per hour (mph) more than attained on level ground in the transmission ratio engaged?

1. 20
2. 15
3. 10
4. 05

8-6. A scraper work cycle has a total of how many phases of operation?

1. One
2. Two
3. Three
4. Four

8-7. To allow material to enter the bowl when loading a scraper, you should ensure the apron is opened by what number of inches above the cutting edge?

1. Between 1 to 3
2. Between 4 to 8
3. Between 9 to 12
4. Between 13 to 15

8–8. What term is used to describe a scraper bowl load that is filled to capacity?

1. Struck load
2. Full load
3. Heaped load
4. Top load

8-9. When a push cat is waiting for a scraper, it should be positioned at what degree angle off the lane to be cut?

1. 90°
2. 75°
3. 45°
4. 15°

8-10. A push cat operator must ensure that the reinforced section of the dozer blade is centered on what component of the scraper?

1. Gooseneck
2. Push block
3. Spill guard
4. Bowl stiffener

8–11. When traveling over a slippery haul road, you should carry the scraper bowl in what manner?

1. As high as possible
2. As low as possible
3. About halfway between the highest and lowest position
4. At the height the material is to be discharged

8-l2. After the apron opening has been adjusted and the dirt flowing through the opening lessens, the operator should engage which of the following levers to finish unloading the scraper bowl?

1. Bowl
2. Apron
3. Ejector
4. Power takeoff

8–13. What term is used to describe the technique of obtaining a heap scraper load of sand?

1. Back-track loading
2. Shuttle loading
3. Optimum loading
4. Pump loading

8-14. At the start of a pump loading operations, an operator should adjust the opening of the apron to how many feet?

1. 1
2. 2
3. 3
4. 4

8-15. Oversize objects, such as large rocks, can cause damage to a scraper by denting, bending, or straining parts.

1. True
2. False

Learning Objective: Recognize the principles of scraper production techniques.

8-16. Which of the following types of loading techniques uses the force of gravity on the scraper to get larger loads in less time?

1. High-speed
2. Downhill
3. Shuttle
4. Straddle

8–17. When you are straddle loading, the island left between the first and second scraper cut should be what width, in feet?

1. 4 to 5
2. 10 to 12
3. 15 to 20
4. 25 to 30

8-18. Which of the following types of loading is used for shortcuts when it is possible to load in both directions?

1. Downhill
2. Straddle
3. Back track
4. Shuttle

8-19. During optimum loading operations, push-loaded scrapers should be loaded within 1 minute and within a maximum distance of how many feet?

1. 25
2. 50
3. 75
4. 100

8-20. Which of the following operations is NOT part of a scraper cycle time?

1. Loading
2. Hauling
3. Refueling
4. Unloading

8-21. Scrapers on the haul road should only travel in the highest gear that is safe for the road.

1. True
2. False

8-22. Which of the following actions should an operator perform if a scraper begins to fall off a fill?

1. Steer downhill
2. Drop the bowl
3. Rapidly accelerate
4. All of the above

Learning Objective: Recognize the principles and components of dozers, tracks, and track frame.

8-23. Dozers are usually rated by size and what other item?

1. Engine size
2. Power
3. Track length
4. Blade width

8-24. Dozer drawbar pull is greatest in the highest transmission gear range.

1. True
2. False

8-25. What is the varying ground bearing pressure range for track equipment?

1. 1 to 4 psi
2. 6 to 9 psi
3. 10 to 15 psi
4. 18 to 20 psi

8-26. What action should an operator perform when operating a dozer in water deep enough to reach the radiator?

1. Tape off the air cleaner
2. Tape off the exhaust stack
3. Disconnect the fan belt
4. Disconnect the batteries

8-27. What component of the dozer contacts the track pin bushings and propels the dozer along the track assembly?

1. Drive sprocket teeth
2. Front idler
3. Carrier rollers
4. Track rollers

8-28. What components, as they wear, will cause the track assembly to lengthen?

1. Grouser shoes and pins
2. Sprocket teeth and bushings
3. Pins and bushings
4. Recoil spring and front idler

8-29. What term is used to describe the most common dozer track shoe?

1. Grouser
2. Cleat
3. Spikes
4. Pads

8-30. What component keeps the track chain in alignment between the drive sprocket and the front idler?

1. Track rollers
2. Lift sheaves
3. Support bearings
4. Carrier rollers

8-31. What component serves as a guiding support for the track chain?

1. Recoil spring
2. Front idler
3. Pitch arm
4. Trunnion roller

8-32. The track adjuster fitting should be lubricated every time daily operator’s maintenance is performed.

1. True
2. False

Learning Objective: Recognize the components and principles of dozer attachments.

8-33. Which of the following attachments are dozer attachments?

1. Blade
2. Ripper
3. Winch
4. All of the above

8-34. Which of the following personnel are responsible for checking the dozer cutting edges for wear?

1. The operations officer
2. The dispatcher
3. The operator
4. The field crew mechanic

8-35. Most push arms are attached to what location on a blade?

1. The top of the blade
2. The center of the blade
3. The front of the blade
4. The bottom of the blade

8-36. A forward blade pitch adjustment is for dozing what type of material?

1. Hard
2. Sandy
3. Salty
4. Loose

8-37. An angle blade can be angled to what amount of degrees to either side?

1. 10°
2. 15°
3. 20°
4. 25°

8-38. Which of the following types of blades drift large volume loads efficiently over long distances?

1. Angle
2. "U"
3. Straight
4. Push

8-39. Which of the following dozer attachments is used to break up compacted materials, to uproot boulders and stumps, and to rip up concrete slabs?

1. Jackhammer
2. Boulder buster
3. Ripper
4. Blade

8-40. The winch line pull is what percentage, if any, greater than a straight dozer pull?

1. 10% to 20%
2. 30% to 40%
3. 50% to 100%
4. None

8-41. When rewinding the wire rope back onto the winch drum, the rigger’s hands should stay clear of the winch drum by at least how many feet?

1. 3
2. 6
3. 9
4. 12

Learning Objective: Recognize the principles of dozer operating techniques.

8-42. Crossing ditches, ridges, rocks, or logs at an angle with a dozer produces which of the following results?

1. Slows the fall
2. Lessens the danger of upsetting the dozer
3. Reduces the jolt of the fall
4. All of the above

8-43. What term is used to describe the operation of removing brush, trees, and rubbish from a designated area?

1. Bulldozing
2. Stumping
3. Clearing
4. Ditching

8-44. What size diameter tree is considered a large tree?

1. 4 inches
2. 6 inches
3. 8 inches
4. 10 inches

8-45. Making contact or releasing pressure on a tree with a dozer should be performed quickly and smoothly to avoid any shock to the tree.

1. True
2. False

8-46. Punctured radiators, broken hydraulic lines, and damaged exhaust stacks are common types of equipment damage that occurs when clearing brush and trees?

1. True
2. False

8-47. What is the most effective piece of equipment for removing rocks and boulders?

1. A dozer with a tilted blade
2. A rock drill
3. A forklift
4. A jackhammer

8-48. What action should an operator perform to increase the digging action of a straight-blade dozer working in hard ground?

1. Tilt the top of the blade rearward
2. Tilt the top of the blade forward
3. Angle the blade to the left
4. Angle the blade to the right

8-49. What is the maximum working distance for a medium-size dozer?

1. 100 feet
2. 200 feet
3. 300 feet
4. 400 feet

8-50. Side–by–side dozing is impractical for hauls of less than what distance?

1. 50 feet
2. 40 feet
3. 30 feet
4. 20 feet

8-51. Slot dozing can increase production up to what percentage?

1. 50%
2. 40%
3. 30%
4. 20%

8-52. What term is used to describe the process of replacing excavated earth?

1. Spreading
2. Finishing
3. Backfilling
4. Ditching

8-53. A sidehill excavation can be started more easily if what type of cut is made first?

1. Ditch
2. Bench
3. Slope
4. Slot

8-54. What position should the dozer blade be in when backing away from the edge of soft fills?

1. As high as possible
2. As low as possible
3. In the float position
4. Angled

8-55. A blade on a straight-blade dozer must have what type of accessory before it can be used as a push dozer?

1. A cutting edge
2. A hard facing
3. A reinforced block
4. A rubber bumper

8-56. An operator of a dozer should always wear a seat belt when dozing.

1. True
2. False

Learning Objective: Recognize the principles and components of rollers.

8-57. What term is used to describe the process of compressing loose soil into a solid mass?

1. Crushing
2. Compaction
3. Pulverizing
4. Condensing

8-58. In roller operations, what does the acronym vpm mean?

1. Vibration per mile
2. Vibration pounding minutes
3. Vibrations per minute
4. Vibrations pulsate moment

8-59. Vibratory rollers achieve compaction through which of the following factors?

1. Weight
2. Impact forces
3. Vibration response
4. All of the above

8-60. The impact forces placed on the soil during compaction are generated by what action of the roller?

1. The weight of the roller
2. The vibration of the drum
3. The kneading effort of the tires
4. The speed of the roller

8-61. A sheepsfoot drum is used for compacting heavy lifts of what thickness range?

1. 3 to 4 inches
2. 6 to 12 inches
3. 12 to 24 inches
4. 24 to 36 inches

8-62. A smooth drum roller is capable of compacting lifts of what thickness range?

1. 4 to 8 inches
2. 8 to 16 inches
3. 16 to 32 inches
4. 32 to 64 inches

8-63. What type of compaction effort is generated by a pneumatic-tired roller?

1. Vibration
2. Pounding
3. Kneading effect
4. Shaking

8-64. The air pressure in the tires of a pneumatic-tired roller should be set at what psi to compact a granular subbase?

1. 40 psi
2. 60 psi
3. 80 psi
4. 100 psi

8-65. What type of roller may fail to compact areas narrower than the roll and does NOT compact deeply in proportion to the roller weight?

1. Sheepsfoot
2. Steel wheel
3. Pneumatic tired
4. Smooth drum

Learning Objective: Recognize the principles of rolling techniques and bituminous rolling.

8-66. When you are performing rolling operations, the roller should travel at what speed range?

1. 1 1/2 to 3 mph
2. 3 1/2 to 6 mph
3. 6 1/2 to 9 mph
4. 9 1/2 to 12 mph

8-67. When rolling a side slope, you should start the rolling process at what location?

1. At the top of the slope
2. At the middle of the slope
3. At the bottom of the slope
4. At a point 5 feet from either the top or bottom of the slope

8-68. What is the optimum temperature range for rolling a hot mix?

1. 100° to 150°
2. 150° to 185°
3. 225° to 285°
4. 300° to 325°

8-69. What is the purpose of keeping roller tires and drums moist when rolling a hot mix?

1. To help cool down the hot mix
2. To keep the hot mix from sticking to the tires and drums
3. To support the curing of the hot mix
4. To clean the tires or drums of foreign materials

8–70. When water is not enough to keep the hot mix from sticking to roller tires and drums, you should use a detergent designed to breakdown grease or oil.

1. True
2. False

8-71. During hot mix construction, at what stage should longitudinal and edge rolling be performed?

1. After breakdown rolling
2. Directly behind the paver
3. After intermediate rolling
4. Before finish rolling

8–72. Breakdown rolling should start at what location on a hot bituminous mat?

1. High side
2. Center
3. Low side
4. Between the low and center

8-73. Which of the following factors must be considered when developing a rolling pattern?

1. Location of first pass
2. Sequence of succeeding passes
3. Overlapping between passes
4. All of the above

B-74. Breakdown rolling with a steel-wheeled roller should be performed with the drive wheel positioned in the direction of travel.

1. True
2. False

8-75. Intermediate rolling should be performed before a hot mix reaches what minimum temperature?

1. 100°
2. 130°
3. 165°
4. 185°

ASSIGNMENT 9

Textbook Assignment: "Cranes and Attachments," pages 12-1 through 12-55.

Learning Objective: Recognize the types and principles of cranes.

9-1. Cranes are classified as what type of equipment?

1. Material handling
2. Load handling
3. Weight handling
4. Cargo handling

9-2. What types of crane carrier or mounting is used by the NCF?

1. Crawler only
2. Truck and crawler only
3. Wheel and truck only
4. Crawler, truck, and wheel

9-3. Crawler-mounted cranes are categorized under what USN number registration series?

1. 37-00000
2. 42-00000
3. 60-00000
4. 82-00000

9-4. It is NOT productive to travel a crawler-mounted crane for more than what distance, in miles?

1. 1
2. 2
3. 3
4. 4

9-5. Crawler–mounted cranes having tracks that extend are rated at what percentage of the minimum weight that can cause the crane to tip?

1. 90%
2. 85%
3. 80%
4. 75%

9-6. Crane radius is measured from what two points?

1. Boom butt to the center of the hook
2. Center of rotation to the boom tip
3. Center of rotation to the center of the hook
4. Boom butt to the boom tip

9-7. Which of the following areas are quadrants of operation for a crawler-mounted crane?

1. Over the side
2. Over the drive end
3. Over the idler end
4. All of the above

9-8. Truck-mounted cranes are categorized under what USN number registration series?

1. 37-00000
2. 42-00000
3. 60-00000
4. 82-00000

9-9. What is the absolute limit of approach for a crane working in an area of power lines that have a current of 125,000 to 250,000 volts?

1. 10 feet
2. 15 feet
3. 20 feet
4. 25 feet

9-10. A boom should rest in the cradle when traveling with a truck-mounted crane equipped with a lattice boom.

1. True
2. False

9-11. Pick and carry crane operations are directed by the crane crew leader.

1. True
2. False

9-12. The capacity of a crane may change when rotating a load from one quadrant to another.

1. True
2. False

9-13. Information concerning a crane capacity in each quadrant of operations can be found at what location?

1. On the equipment status board
2. In the rigging loft
3. On the crane load chart
4. In the dispatch office

Learning Objective: Recognize the components of lattice and telescopic boom cranes.

9-14. A basic boom consists of which of the following components?

1. The boom butt, a 10 foot extension, and a boom tip
2. The boom butt, boom tip, and a jib
3. The boom butt and a boom tip
4. The boom butt, a 20-foot extension, and a boom tip

9-15. Manufacturers have set a zero tolerance for what type of defect(s) or damage to any area of a lattice boom?

1. Rust
2. Bent lacings or cords
3. Cracked welds
4. All of the above

9-16. Which of the following NAVFAC publications contains the set guidelines for cranes having structural damage?

1. P–405
2. P–307
3. P–306
4. P-300

9-17. The rule of thumb used when mixing short boom sections with long sections is to install the longer sections closest to the boom butt.

1. True
2. False

9-18. An operator of a crane should NOT rely on the boom angle indicator for radius accuracy especially when lifts exceed what percentage of the rated capacity?

1. 60%
2. 65%
3. 70%
4. 75%

9-19. Each boom section has two pendants. If one pendant is bad, both pendants must be replaced.

1. True
2. False

9–20. On most cranes, the function of the jib is to increase the lift height.

1. True
2. False

9-21. The bridle assembly is the connection point for which of the following components of a crane?

1. Fairlead
2. Pile driver hammer
3. Pendant lines
4. Master clutch

9-22. Boom stops are designed to prevent the boom from going-over backwards in the event what problem occurs?

1. The boom bounces out of the cradle during transport
2. A load line breaks
3. The operator leaves the boom hoist lever engaged
4. The operator swings the crane too fast

9-23. What is the function of the master clutch?

1. Provides the mechanism to lift and lower loads
2. Transmits engine power to the transmission
3. Engages the power from the power source to the hoist and swing mechanisms
4. Rotates the house assembly

9-24. Which of the following types of crane operations would require the use of two hoist drums?

1. Clamshell
2. Dragline
3. Pile driving
4. All of the above

9-25. What component of a crane plays an important part when changing the length of the boom?

1. The bridle assembly
2. The main hoist line
3. The counterweight
4. The master clutch

9-26. When lowering the boom to the ground, the boom point sheaves should set on a piece of dunnage.

1. True
2. False

9-27. Before a crane can be put back in service, which of the following instructions states the crane test director must inspect the crane for correct installation of all components?

1. COMSECOND/COMTHIRDNCBINST 11200.1
2. COMSECOND/COMTHIRDNCBINST 11200.23
3. COMSECOND/COMTHIRDNCBINST 4400.3
4. COMSECOND/COMTHIRDNCBINST 1500.20

9-28. When telescopic boom sections are extended unequally, uneven stresses are placed on the most retracted section.

1. True
2. False

Learning Objective: Recognize the components of crane attachments.

9-29. The number of part lines rigged on a hook block is NOT a factor when figuring the capacity of a crane.

1. True
2. False

9-30. In order to operate, which of the following attachments requires the use of a tag line, a holding line, and a closing line?

1. Concrete bucket
2. Clamshell
3. Dragline
4. Pile hammer

9-31. Which of the following components helps prevent the clamshell from twisting during clamshell operations?

1. Fairlead
2. Closing line
3. Tag line winder
4. Bridle assembly

9-32. A fairlead performs what function during crane operations?

1. Keeps the clamshell from twisting
2. Guides the drag cable onto the hoist drum
3. Guides the boom hoist cable through the gantry
4. Supports the pile hammer during pile-driving operations

9-33. A drag cable should be lubricated each time operator maintenance is performed on a crane.

1. True
2. False

Learning Objective: Recognize the principles of crane operations.

9-34. What factor is the cause of most crane mishaps?

1. Mechanical error
2. Operator error
3. Natural disasters
4. Design flaws

9-35. Which of the following COMSECOND/COMTHIRDNCBINST provides guidelines for wire rope slings and rigging hardware used in the NCF?

1. 11200.8
2. 11200.9
3. 11200.11
4. 11200.22

9-36. Before receiving a license to operate a crane, operators are required to attend what total number of hours of formal classroom instruction?

1. 8
2. 16
3. 32
4. 40

9-37. It is very dangerous for personnel to control crane suspended loads by their hands instead of a tag line.

1. True
2. False

9-38. Which of the following personnel has the ultimate responsibility for a crane lift?

1. The signalman
2. The operator
3. The oiler
4. The rigger

9-39. Which of the following forms is used when performing crane prestart inspections and is turned in to the crane crew supervisor at the end of each day or shift for reviewing and signing?

1. An ODCL
2. A hard card
3. An Operator’s Inspection Guide
4. An Operator’s Daily PM report

9-40. Wire rope should be replaced when wear has destroyed what fraction of the original diameter of the outside individual wires?

1. 1/8
2. 1/3
3. 1/2
4. 2/3

9-41. Which of the following sockets can develop only 70 percent of the breaking strength of the wire rope?

1. Swage socket
2. Cappel socket
3. Spelter socket
4. Wedge socket

9-42. “Two-blocking” means hoisting the hook block sheaves against the boom tip sheaves.

1. True
2. False

9-43. Which of the following personnel is responsible for filling out the crane lift checklist?

1. The rigger
2. The signalman
3. The crane crew supervisor
4. The crane test mechanic

9–44. The rated capacities of mobile cranes are based on what two factors?

1. Width and Length
2. Strength and stability
3. Rigging and winch pull capacity
4. Drawbar pull and mobility

9-45. In situations where crane outriggers cannot be fully extended, you determine the load capacity of a crane by using the “without outriggers” load capacity ratings.

1. True
2. False

9-46. The boom angles for clamshell operations should normally be between what boom angle degrees?

1. 20° to 30°
2. 30° to 40°
3. 40° to 60°
4. 60° to 80°

9-47. The boom angle for dragline operations should normally be between what boom angles degrees?

1. 25° to 35°
2. 35° to 45°
3. 45° to 55°
4. 55° to 65°

Learning Objective: Recognize the components and types of pile-driving leads used in the NCF.

9-48. A pile-driving hammer is categorized under what USN number registration series?

1. 82-00000
2. 60-00000
3. 42-00000
4. 36-00000

9-49. The combined weight of all pile-driving attachments reduces the capacity of the crane.

1. True
2. False

9-50. Pile–driving leads serve what function during pile-driving operations?

1. As tracks for the pile-driving hammer
2. As a guide for positioning a pile
3. As guides for steadying a pile
4. All of the above

9-51. During what time period should pile-driving lead bolts be checked for tightness?

1. At the beginning of each day
2. At the beginning of each week
3. At the beginning of each month
4. At the beginning of each shift

9-52. What type of lead is held plumb or at the desired batter with the second single crane line?

1. Swinging
2. Underhung
3. Extended four-way
4. Overhead

9-53. What type of lead is connected to the boom tip through the use of lead adapters?

1. Swinging
2. Underhung
3. Extended four-way
4. Overhead

9-54. During what time period should lead adapter bolts be checked for tightness?

1. At the beginning of each day
2. At the beginning of each week
3. At the beginning of each month
4. At the beginning of each shift

9-55. What component is used to hold leads at a vertical for driving bearing piles or to hold the leads at an angle for driving batter piles?

1. A tag line winder
2. A bridle assembly
3. A catwalk
4. A boom mast

9-56. What type of lead uses a sliding boom tip connector for connecting the boom tip of the crane to the leads?

1. Swinging
2. Underhung
3. Extended four-way
4. Overhead

9-57. What type of lead has an advantage over other leads because it bears the entire bottom of the pile cap to the piling?

1. Swinging
2. Spud
3. Extended four-way
4. Underhung

Learning Objective: Recognize the principles and components of pile–driving hammers.

9-58. The noise generated by a pile–driving operation can cause hearing loss.

1. True
2. False

9-59. The DE-10 hammer is lifted and started by a single crane line connected to what hammer component?

1. Fuel pump assembly
2. Belleville spring assembly
3. Trip mechanism
4. Thrust bearing

9-60. The compression of the trapped air in the DE-10 hammer creates a preloading force upon which of the following components?

1. Anvil
2. Drive cap
3. Pile
4. All of the above

9-61. What component in the DE–10 hammer is designed to break or bend in the event the operator lowers the trip mechanism to low during hammering operations?

1. Dowel pin
2. Safety link
3. Throttle shaft
4. Lifting hook

9-62. On a diesel hammer, gasoline is fed by gravity from the main fuel tank through the filter cartridge.

1. True
2. False

9-63. Lubricating oil for a diesel hammer should have a flash point of what degrees, in Fahrenheit?

1. 225°F to 250°F
2. 325°F to 350°F
3. 425°F to 450°F
4. 525°F to 550°F

9-64. What component of a diesel hammer has compression rings and is held in place by buffet bolts?

1. The ram piston
2. The universal drive cap
3. The vibration damper
4. The anvil block

9-65. The length of free travel of the ram-piston from the bottom of the stroke to the safety catch lip at the top is what length, in inches?

1. 69
2. 89
3. 109
4. 118

9-66. The top of the cushion block should be high enough to prevent the hammer shroud from fouling on the rim of the drive cap.

1. True
2. False

9-67. What term is used to describe a pile-driving hammer driving piles without the use of leads?

1. Free hammer
2. Flying hammer
3. Floating hammer
4. Glide hammer

Learning Objective: Recognize principles of pile–driving techniques and terminology.

9-68. What term is used to describe when a pile vibrates too much laterally from the blow of the hammer?

1. Springing
2. Bouncing
3. Refusal
4. Bearing

9-69 . What term is used to describe the condition reached when a pile being driven by a hammer has a 1-inch penetration per blow?

1. Springing
2. Bouncing
3. Refusal
4. Bearing

9-70. What term is used to describe a pile supported by skin friction alone?

1. Bearing
2. Batter
3. Lateral
4. Friction

9-71. The longer a pile stays in the soil the more compact the soil becomes; therefore, the greater the resistance to pulling will be.

1. True
2. False

9-72. What term is used to describe a group of piles driven close together in water and tied together so that the group will withstand lateral forces?

1. Batter
2. Anchor
3. Dolphin
4. Fender

9-73. What type of pile is made by pouring concrete into a tapered hole or cylindrical form previously driven into the ground?

1. Precast concrete
2. Cast-in–place concrete
3. Composite
4. Sheet

9-74. Which of the following piles is a commonly used type of sheet pile?

1. Straight web
2. Shallow arch
3. Deep arch
4. All of the above

9-75. Which of the following types of sheet piles are designed for maximum flexibility and tensile strength?

1. Straight web
2. Shallow arch
3. Deep arch
4. Z web

ASSIGNMENT 10

Textbook Assignment: "Rigging" and "Miscellaneous Equipment" pages 13–1 through 14-22.

Learning Objective: Recognize the parts, grades, and characteristics of wire rope.

10-1. What term is used to describe a wire rope that has strands or wires that are shaped to conform to the curvature of the finished rope?

1. Non–preformed wire rope
2. Preformed wire rope
3. Non-conform wire rope
4. Conform wire rope

10-2. Which of the following component are part of the construction of a wire rope?

1. Wires
2. Strands
3. Core
4. All of the above

10-3. Wire rope is designated by the number of strands per rope and what other factor?

1. The length of the strand
2. The diameter of the strand
3. The number of wires in each strand
4. The number of strands in each wire

10-4. Which of the following strand constructions has alternating large and small wires that provide a combination of great flexibility with a strong resistance to abrasion?

1. Ordinary
2. Scale
3. Warrington
4. Filler

10-5. Which of the following types of wire rope cores is a separate wire rope over which the main strands of the rope are laid?

1. Fiber
2. Wire strand
3. Independent wire rope
4. Unconstrained wire rope

10–6. Each square inch of improved plow steel can withstand a strain that is within what range, in pounds of pressure?

1. Between 100,000 to 140,000
2. Between 240,000 to 260,000
3. Between 300,000 to 340,000
4. Between 440,000 to 460,000

10-7. Which of the following wire rope lays has the wires in the strands laid to the right, while the strands are laid to the left to form the wire rope?

1. Left lang lay
2. Right regular lay
3. Right lang lay
4. Left regular lay

10-8. Because it is very flexible, which of the following types of wire rope is acceptable for use on cranes?

1. 6 x 12
2. 6 x 19
3. 6 x 24
4. 6 x 37

10-9. What is the SWL of a 3/4-inch wire rope?

1. 4.5 tons
2. 6 tons
3. 12 tons
4. 13.5 tons

Learning Objective: Recognize the principles for the handling and care of wire rope and wire rope attachments.

10–10. What type of wire rope damage starts with the formation of a loop?

1. Crush spots
2. Wear spots
3. Kinks
4. Broken wires

10–11. Too large of a fleet angle can cause a wire rope to climb a flange of a sheave.

1. True
2. False

10–12. In wire rope rigging, the diameter of a sheave should never be less than how many times the diameter of the wire rope?

1. 10
2. 20
3. 30
4. 40

10–13. What total number of seizing is required for seizing a 7/8-inch wire rope?

1. 1
2. 2
3. 3
4. 4

10–14. Wire rope deterioration from corrosion is more dangerous than that from wear.

1. True
2. False

10-15. What wire rope lubricant ratio is recommended by the COMSECONO/COMTHIRDNCBINST 11200.11?

1. 70–percent diesel fuel to 30-percent new motor oil
2. 70–percent used motor oil to 30–percent diesel fuel
3. 70–percent gasoline to 30-percent used motor oil
4. 70-percent new oil to 30–percent diesel fuel

10-16. What term is used to describe the technique of attaching a socket to a wire rope by pouring hot zinc around it?

1. Seizing
2. Sheltering
3. Swaging
4. Wedging

10–17. A rule of thumb used when attaching a wire rope clip to a wire rope is “never saddle a live horse.”

1. True
2. False

10–18. To form an eye with a 3/4-inch wire rope would required what total number of wire rope clips?

1. One
2. Two
3. Three
4. Four

10–19. Wire rope eyes with thimbles and wire rope clips can hold approximately what percentage of the strength of a wire rope?

1. 60%
2. 70%
3. 80%
4. 90%

10–20. At a swaged connection, what is the maximum amount of broken wires allowed before the swaged fitting should be replaced?

1. One
2. Two
3. Three
4. Four

10-21. When a hook has been bent by overloading, the hook should be straightened by heating the hook with a torch.

1. True
2. False

10-22. When an original shackle pin is lost or does not fit properly, the shackle should NOT be used.

1. True
2. False

Learning Objective: Recognize the principles and components of fiber line and chains.

10–23. Which of the following types of fiber line comes from the leaf stems of the stalk of the abaca plant?

1. Sisal
2. Manila
3. Cotton
4. Hemp

10-24. Which of the following types of fiber line is principally used in fittings, such as ratline, marline, and spun yarn?

1. Sisal
2. Manila
3. Cotton
4. Hemp

10–25. The snapback of a nylon rope can be as deadly as a bullet.

1. True
2. False

10-26. What percentage of extension in length is the critical point of loading for a nylon rope?

1. 10%
2. 20%
3. 30%
4. 40%

10-27. What type of fiber line has characteristics similar to that of nylon line, but does not snapback when it parts?

1. Sisal
2. Hemp
3. Kevlar
4. Manila

10-28. For some jobs, which of the following properties make chain more suited for use than wire rope?

1. Resistant to abrasion
2. Resistant to corrosion
3. Resistant to heat
4. All of the above

10-29. Which of the following conditions affects the strength of a chain?

1. Knotting the chain
2. Overloading the chain
3. Heating the chain to temperatures above 500°F
4. All of the above

10-30. Chains should be removed from service when any link shows wear that exceeds what percentage of the thickness of the metal?

1. 10%
2. 15%
3. 20%
4. 25%

Learning Objective: Recognize the principles and components of slings.

10-31. In the NCF, at what location are the 80104, 84003, and 84004 kits maintained?

1. Collateral equipage
2. Central toolroom
3. Mechanic shop
4. Rigging loft

10-32. The bridle hitch provides excellent load stability when which of the following conditions exists?

1. The load is distributed equally among each sling leg
2. The load hook is directly over the center of gravity of the load
3. The load is raised level
4. All of the above

10-33. With a four-legged bridle sling lifting a rigid load, it is possible for two of the sling legs to support practically the full load while the other two legs only balance it.

1. True
2. False

10-34. What degree sling angle is considered extremely hazardous and must be avoided?

1. 55°
2. 50°
3. 45°
4. 30°

10-35. A three- or four–leg hitch can safely lift a load equal to the safe load on one leg multiplied by the number of legs.

1. True
2. False

10-36. The 80092 kit contains the tools and equipment necessary to fabricate a wire rope with a diameter that ranges from 3/8 inch to what maximum size?

1. 5/8 inch
2. 3/4 inch
3. 7/8 inch
4. 15/16 inch

10–37. What factors about a wire rope sling must you know in order to use the rated capacity charts that are enclosed in the COMSECOND/ COMTHIRDNCBINST 11200.11?

1. Diameter
2. Type core
3. Type grade
4. All of the above

Learning Objective: Recognize the principles of mechanical advantage.

10-38. What term is used to describe an assembly of blocks and lines used to gain a mechanical advantage in lifting and pulling?

1. Two blocked
2. Tackle
3. Overhaul
4. Breech

10-39. With fiber line, the length of the block used should be approximately what size compared to the line?

1. Three times the circumference of the line
2. Four times the circumference of the line
3. Five times the circumference of the line
4. Six times the circumference of the line

10-40. Which of the following chain hoists has an efficiency of 85 percent?

1. Screw gear
2. Differential chain
3. Spur gear
4. Spindle gear

10-41. The capacity of a winch may be reduced by what percentage when the last layer of wire rope is being wound onto the winch drum?

1. 30%
2. 40%
3. 50%
4. 60%

10-42. To avoid placing shock on a set of slings, you should start a crane lift quickly and smoothly.

1. True
2. False

Learning Objective: Recognize the principles of mixing and drilling equipment.

10-43. On a transit mixer, how many revolutions of the drum at the rate of rotation is usually required to produce a specified uniformity mix of concrete?

1. 10 to 40
2. 40 to 70
3. 70 to 100
4. 100 to 140

10-44. Concrete, mixed in a transit mixer, should be delivered within 1 1/2 hours or before the drum has revolved a maximum of how many times after the introduction of water?

1. 100
2. 200
3. 300
4. 400

10-45. A loaded transit mixer has been down for more than an hour. To keep the concrete from setting up inside the truck, you should add a total of how many pounds of sugar to the concrete?

1. 2 pounds
2. 5 pounds
3. 10 pounds
4. 15 pounds

10-46. The crete mobile carries which of the following ingredients in divided bins mounted on the unit?

1. Cement
2. Sand
3. Coarse aggregates
4. All of the above

10-47. The mixing action of a crete mobile is a continuous process that can proceed until the aggregate bins are empty.

1. True
2. False

10-48. To keep an earth auger from bouncing, when working in hardpan or rocky soil, an operator should take what action.

1. Increase the engine rpm
2. Slip the clutch
3. Use support jacks
4. Increase the air pressure in the tires

10-49. To clean the drilling components of dirt when raising the auger bit from a drilling hole, you should take which of the following actions?

1. Increase the drill rpm
2. Lower the engine speed
3. Tilt the auger fore and aft while the engine is running
4. Tilt the auger fore and aft while slowly pulling the bit out of the hole

10-50 . On the earth auger, the auger head is attached to the drill shank by square-drive pin connectors.

1. True
2. False

10-51. In addition to keeping the drill hole alignment straight, the pilot cutter on an auger serves what other function?

1. Protects the drill head from overheating
2. Makes cutting easier with larger auger heads
3. Acts as a safety link between the cutting edge and auger shank
4. Makes it easier to change drill heads

10-52. Before performing any drilling or boring operations, you must have a digging permit and have all underground utilities and obstructions clearly marked and identified.

1. True
2. False

Learning Objective: Recognize the principles of compressed air equipment and tools.

10-53. Most compressors used in the Naval Construction Force are governed by a pressure control system that is adjusted to compress air to a maximum pressure of how many pounds per square inch (psi)?

1. 90
2. 100
3. 150
4. 200

10-54. All reciprocating, rotary, and screw compressors are classified as one of what two types?

1. Either fast or slow acting
2. Either double or triple stage
3. Either single stage or multistage
4. Either portable or non–portable

10-55. A multistage air compressor system is more efficient than a single-stage system because the air cooled between stages in the multistage provides what advantage?

1. Increases the temperature of the compressed air
2. Reduces buildup of pressure due to temperature rise
3. Has the capacity to hold more air at a higher pressure
4. Compresses the air to one thousandth of its original size

10-56. To supply compressed air over a distance of more than 200 feet for hand tool operations, you must use what attachment?

1. An air manifold
2. A number 4 coupler
3. A larger diameter hose
4. A smaller diameter hose

10–57. Compressors of different types should NOT be used on the same manifold because of what factor?

1. The difference in distance between two or more compressors could cause the overloading or underloading of either compressor
2. The difference in pressure control systems on different types of compressors could cause one compressor to be overloaded, while the other is idled
3. The manifold could explode due to uneven air pressure from two compressors
4. The uneven flow of air pressure would starve the tools of the correct amount of required air

10-58. Pneumatic tools can be used with any type or size of compressor as long as what two requirements of the tool are met?

1. Psi and lubrication
2. Cfm and lubrication
3. Air regulation and lubrication
4. Psi and cfm

10-59. What is the major difference between a pavement breaker/ jackhammer and a rotary rock drill/jackhammer?

1. The pavement breaker has a rotational mechanism and a variation of speeds are available, while the rotary rock drill has only one speed
2. The rotary rock drill has a rotational mechanism and a variation in speed, while the pavement breaker has only one speed
3. The cutting bits of the pavement breaker will fit the rotary rock drill, while the cutting bits of the rock drill will not fit the pavement breaker
4. The drill design of the pavement breaker, unlike that of the rotary rock drill, directs air through the drill, down the drill steel, and into the bottom of the hole to blow out the cuttings

10-60. Which of the following pavement breaker attachments is best suited for trimming corners and splitting seamed rock?

1. Moil point
2. Chisel point
3. Asphalt cutter
4. Clay spade

10-61. The rotary rock drill is a piston rotary unit designed mainly for what purpose?

1. Hard rock drilling
2. Shallow depth rock drill
3. Medium depth rock drill
4. Deep boring rock drill

10-62. The fourth class rotary rock drill weighs from 50 to 65 pounds and is used for drill holes up to a maximum of how many feet?

1. 18
2. 12
3. 10
4. 6

10-63. On the blower type of drill, cuttings are removed in what manner?

1. By blowing water from the bottom of the hole
2. By a steady supply of air passing through the drill steel
3. By stopping the drill and blowing the cuttings out through the drill steel
4. By stopping the drill and blowing the hole for 30 seconds after every 2 feet or 1 minute of drilling operations

10-64. Drill manufacturers recommend installing the in-line oiler within how many feet from the drill?

1. 10 to 12 feet
2. 15 to 20 feet
3. 20 to 25 feet
4. 25 to 30 feet

10-65. Which of the following pneumatic tools is built for heavy-duty use on timber construction work and may be used for ripping as well as cross cutting?

1. Chain saw
2. Nail driver
3. Drill
4. Circular saw

Learning Objective: Recognize the principles of the crawler-mounted rock drill.

10-66. The crawler-mounted rock drill is a self-propelled unit designed primarily to perform which of the following operations?

1. Drill water wells
2. Drill auger holes
3. Drill vertical holes only
4. Drill vertical and angular blast holes in rock

10–67. The compressor discharge air volume of the rock drill is what maximum cfm?

1. 230
2. 200
3. 130
4. 100

10–68. The feed motor is capable of exerting a maximum pull up of how many pounds?

1. 2,410 pounds
2. 3,410 pounds
3. 4,410 pounds
4. 5,410 pounds

10-69. Which of the following control levers is used when drilling boreholes and coupling and uncoupling drill steel?

1. The fast feed
2. The drill
3. The rotation
4. The slow speed

10-70. What is the function of the vaposol system?

1. To throw a mist down the blow hole to control dust
2. To throw a mist through the drill steel to control cooling
3. To throw a mist around the drill area to control dust
4. To throw a mist down the borehole to achieve the optimum moisture content required for compaction of a blast hole

10–71. Before drilling, the blow air pressure gauge should indicate what minimum psi?

1. 50
2. 100
3. 150
4. 200

10-72. Improper feed pressure results in poor penetration rates and shortens the life of which of the following components?

1. The feed chain
2. The rod
3. The sleeve and shank
4. All of the above

10-73. The drill steel should be rotated or changed after drilling what maximum number of boreholes?

1. One
2. Two
3. Three
4. Four

10-74. Safety guidelines for rock drill operations are outlined in what U.S. Army manual?

1. EN 5478
2. EN 5258
3. TM 5-331
4. EM 385-1-1

10-75. Visitors to rock drill operations, unless suited properly with all required safety gear, must stay clear at a distance of what minimum distance?

1. 25 feet
2. 50 feet
3. 75 feet
4. 100 feet

ASSIGNMENT 11

Textbook Assignment: "Miscellaneous Equipment" and "Earthwork Operations," pages 14–22 through 15-37.

Learning Objective: Recognize the principles and components of floodlights, generators, and lubricators.

11–1. Floodlights used by the Naval Construction Force (NCF) are designed to operate in which of the following climatic conditions?

1. Dry
2. Wet
3. Cold
4. All of the above

11–2. You should NOT use a light plant as a power source for power tools because the power surge and power draw from the tools can overload the exciter and result in damage to the generator.

1. True
2. False

11–3. What is one of the first requirements you must ensure is met before placing a light plant in operation?

1. Adequate ventilation is available
2. The unit is at a 30–degree incline
3. The unit is jacked up off the ground and level
4. All circuits are closed

11-4. If a light plant engine idles down while the generator is excited, what damage is likely to occur to the light plant generator?

1. The main fuse will blow
2. The clutch will overheat
3. The circuits will melt
4. The field winding will burn

11-5. Placing a generator near points of large demand provides which of the following advantages?

1. Reduces the size of wire required
2. Holds line loss (voltage) to a minimum
3. Provides adequate voltage control at the remote ends of the line
4. All of the above

11–6. A generator should NOT be operated on an incline that exceeds what maximum degrees from level?

1. 10
2. 15
3. 20
4. 25

11-7. A solid ground rod must have a minimum diameter of how many inches?

1. 1/4
2. 1/2
3. 5/8
4. 3/4

11-8. The ground rod is accountable collateral gear for a generator.

1. True
2. False

Learning Objective: Recognize the principles and components of lubricators, pumps, and sweepers.

11-9. When removing a grease gun from a fitting, you should take what action to avoid damaging the fitting or the grease gun coupler?

1. Twist the coupler to one side
2. Pull the coupler straight back
3. Work the coupler up and down as you apply backward pressure
4. Give the coupler a short, hard pull

11-10. Overgreasing equipment can cause damage to seals and packings.

1. True
2. False

11-11. What does the acronym MSDS mean?

1. Material Supply Dispatch System
2. Mud Slinging Drill System
3. Material Safety Data Sheet
4. Management Systems Design Specialists

11-12. A pump uses what type(s) of force to move liquid from one point to another?

1. Pushing only
2. Pulling and pushing only
3. Throwing and pulling only
4. Pushing, pulling, and throwing

11-13. What term is used to describe the part of a pump where mechanical motion is applied to the liquid being pumped?

1. Liquid end
2. Rotating end
3. Power end
4. Prime mover end

11-14. In a diaphragm pump, what force moves the liquid from intake to discharge?

1. Centrifugal motion
2. Rotary motion
3. Reciprocating motion of a flexible diaphragm
4. A rocking motion of a impeller

11-15. The mud hog and water hog are what type of pumps?

1. Centrifugal
2. Diaphragm
3. Rotary
4. Gear

11-16. Fluid entering the centrifugal pump is first directed in what location?

1. The diaphragm
2. The blades of the rotor
3. The center of the impeller
4. The splines of the fan clutch

11-17. When you are starting a centrifugal pump, the discharge valve should be in what position?

1. Open
2. Run
3. Stop
4. Closed

Learning Objective: Recognize the principles and components of sweepers and snow removal equipment.

11-18. A pull type of sweeper removes debris from a sweep area in which of the following ways?

1. By windowing debris to the side
2. By vacuuming up debris
3. By washing the debris
4. By pushing the debris straight ahead of the sweeper

11-19. You are planning to use a rotary street sweeper to sweep streets. You should check the availability of what sweeping requirement along the route?

1. Fuel
2. A place to dispose of debris
3. Water
4. Air

11–20. A magnetic sweeper has what components that help prevent damage to the sweeper when an obstruction is encountered?

1. A skid plate and spring
2. Heavy springs and a bumper
3. Wheels on each side
4. A swing arm and guide

11-21. Debris collected by a magnetic sweeper is dumped in which of the following ways?

1. By shutting down the engine
2. By releasing the collector hopper dump lever
3. By idling down the engine throttle
4. By shutting off the magnetic circuit breaker

11-22. Which of the following types of snow removal blades has a tapered moldboard formed to give snow a lifting, rolling action and can throw snow a considerable distance?

1. Reversible blade
2. Combination blade
3. Roll-over blade
4. "U"-blade

11-23. When you are plowing snow with a roll-over blade, the blade hoist lever should be in what position?

1. Float
2. Lowered
3. Raised
4. Hold

11-24. What action occurs when an object jams the blower?

1. The blower continues to chew at the object until it passes through the blower
2. The auger is spring-loaded back into position after the object passes
3. A shear pin breaks
4. A jaw clutch allows the auger to slip

11-25. You are operating snow removal equipment. To prevent picking up and blowing rocks, you should perform which of the following actions?

1. Install a rock rake in front of the blower
2. Stretch a length of chain across the bottom of the blade
3. Reduce the spring tension on the blower
4. Raise the blower a couple of inches off the ground

11-26. A motor grader can be used for snow removal on runways and taxiways.

1. True
2. False

11-27. When plowing snow, an operator can prevent the grader cutting edge from damaging the pavement surface by performing which of the following actions?

1. Keeping the cutting edges an inch above the surface
2. Keeping the grader at a slow speed
3. Replacing the cutting edge with a rubber strip
4. Reversing the blade

11-28. When removing piles of snow with a loader, you should take what action to ensure that no fireplugs are under the pile?

1. Use a pole to stick into the pile to check for obstructions
2. Check the utilities plan
3. Use a guide to look for the fireplug
4. Use the back of the bucket as a feeler

11-29. Which of the following types of sand effectively produces traction on iced surfaces?

1. Wet sand
2. Dry sand
3. Cold sand
4. Hot sand

11-30. What factor makes loose sand less effective than hot sand for gaining traction?

1. It may be blown off the surface by wind and traffic
2. It is difficult to spread
3. It freezes in the truck
4. It makes the ice more slick

Learning Objective: Recognize the principles of project planning.

11-31. Earthwork operation is classified as vertical construction?

1. True
2. False

11-32. Which of the following construction phases are documented in a standard nine-folder project package?

1. Initial planning
2. Execution
3. Closeout
4. All of the above

11-33. In a standard nine-folder project package, which of the following documents are placed in the right hand side of file Number 8?

1. Bill of materials
2. Resource leveled plan for manpower and equipment
3. Safety plan
4. Project plans

11–34. Step-by-step information on how a project package is developed is outlined in which of the following COMSECOND/COMTHIRDNCBINST?

1. 5200.2X
2. 1500.20G
3. 5100.1
4. 5600.1E

11-35. Which of the following functions does a project drawing NOT provide?

1. The basis for estimating material
2. Precise instructions for construction, showing the sizes and locations of various parts
3. Step-by-step instructions of how construction is to be performed
4. A means of coordination between the different ratings

11–36. A contour line is a symbol that shows an imaginary line that represents a constant elevation on the surface of the earth.

1. True
2. False

11-37. Which of the following disadvantages occur when utility lines are ripped up?

1. Loss of project time
2. Increased project cost
3. People supported by the utilities are inconvenienced
4. All of the above

Learning Objective: Recognize the principles of earthwork computations.

11-38. Earthwork computations are the calculations of earthwork volumes used to determine which of the following factors?

1. The final grade
2. A balanced cut and fill
3. A plan for the most economical movement of material
4. All of the above

11-39. A cubic yard is 3 feet long, 3 feet wide, and what height, in feet?

1. 1
2. 2
3. 3
4. 4

11-40. In planning, which of the following conditions is NOT a state of condition considered when computing cubic yards of material?

1. In place
2. Wet
3. Loose
4. Compacted

11-41. What term is used to describe a selected layer of well-compacted soil that is placed in compacted lifts on top of the subgrade?

1. Crown
2. Base course
3. Surface course
4. Backslope

11-42. What term is used to describe the section of a ditch that extends from the outside of the shoulder to the bottom of the ditch?

1. Foreslope
2. Roadbed
3. Backslope
4. Travelway

11-43. A cross-sectional view of project prints displays the slope limits, the slope ratio, and the horizontal distance between the centerline stakes and the shoulder stakes?

1. True
2. False

Learning Objective: Recognize the principles of construction (grade) stakes.

11-44. Which of the following describes grade work?

1. Making cuts or fills with any limit of grade and alignment
2. Making cuts or fills to a definite limit of grade and alignment
3. Aligning survey stakes on a construction project
4. Taking the ground irregularities of a project and plotting them on a blueprint

11-45. A hub stake with a red or blue top is used for what type of grade work?

1. Finished
2. Rough
3. Profile
4. Alignment

11-46. A guard stake provides which of the following services?

1. Warns the oncoming traffic of construction ahead
2. Protects construction workers from traffic
3. Warns the operator that a flag is ahead
4. Provides a means of locating a reference point

11-47. What term is used to describe the reference mark on a grade stake that indicates the actual grade desired?

1. Arrowhead
2. Sheepsfoot
3. Crowfoot
4. All of the above

11-48. Stakes used on construction projects are normally marked in what unit (s) of measurement?

1. Feet only
2. Feet and tenths of a foot
3. Meters only
4. Meters and centimeters

11-49. To convert tenths of a foot to inches, you multiply the decimal fraction by what number?

1. 6
2. 8
3. 10
4. 12

11-50. Which of the following station numbers identifies the starting station?

1. 0 + 00
2. 1 + 00
3. 10 + 00
4. 100 + 00

11-51. A grade stake station that ends with the number 00 is known by what term?

1. Even
2. Plus
3. Full
4. Midway

11-52. What type of stake marks the horizontal location of earthwork and gives the direction of the proposed construction?

1. Centerline
2. Line
3. Shoulder
4. Slope

11-53. Rough alignment stakes are used for what purpose?

1. To mark the project boundaries
2. To mark trees that are not to be cleared
3. To mark the control points for the survey crew
4. To mark the straightaway

11-54. What information is written on the front of a centerline stake?

1. Change in elevation
2. Crowfoot
3. Station number
4. Offset information

11-55. On a road project, a grade stake with the symbol SH should be placed at what location?

1. On a line parallel to the center line
2. Not more than 20 feet from the center line
3. Only on the back side of a fill or cut stake
4. On the back side of the centerline stake

11-56. What information should be marked on the face of a shoulder stake that is facing the center line of a road?

1. Cut and fill data
2. Station number
3. Distance across the road
4. Right-of-way data

11-57. What term is used to describe raising the elevation of the ground?

1. Raise
2. Lift
3. Fill
4. Elevation adjustment

11-58. A stake marked "OF 65′ CL C-3.5" means that the stake is offset what distance from the centerline stake?

1. 3 feet
2. 3.5 feet
3. 65 feet
4. 68.5 feet

Learning Objective: Recognize the principles and components of leveling equipment.

11-59. A hand level is NOT used at distances that exceed what number of feet?

1. 20
2. 30
3. 40
4. 50

11-60. When used for alignment, a dumpy level is accurate at distances up to how many feet?

1. 1,000
2. 2,000
3. 3,000
4. 4,000

11–61. A compensator on a self-leveling level automatically places the line of sight horizontal.

1. True
2. False

11–62. When placing a leveling instrument on a tripod, you should torque the instrument down until it binds to the screw threads.

1. True
2. False

11-63. Each foot on a Philadelphia rod is subdivided into what fraction of a foot?

1. Tenth
2. Hundredth
3. Thousandth
4. Ten–thousandth

11-64. The indicators for foot measurements on a Philadelphia rod are what color?

1. White
2. Black
3. Red
4. Brown

11-65. What person makes the rod reading when a target is used?

1. Levelman
2. Rodman
3. Signalman
4. Targetman

11-66. What term is used to describe a reference point whose elevation is known and marked?

1. Datam plane
2. Mean sea level
3. Bench mark
4. Backsight

11-67. To determine the height of the instrument, you add the bench mark elevation to what reading taken from the level rod?

1. Mean sea sight
2. Sidesight
3. Foresight
4. Backsight

11-68. The height (HI) of the instrument is 136 feet. The foresight (FS) reading is 4.5 feet. What is the elevation at the foresight reading?

1. 91 feet
2. 132.5 feet
3. 140.5 feet
4. 171 feet

11-69. In setting or replacing grade stakes, you should measure horizontal distance with which of the following types of tapes?

1. Metallic woven
2. Nonmetallic woven
3. Steel
4. All of the above

11-70. Which of the following incremental markings are on a steel surveyor’s tape?

1. Feet, tenths of a foot, and hundredths of a foot
2. Feet, tenths of a foot, and yards
3. Yards, feet, and hundredths of a foot
4. Feet and yards only

Learning Objective: Recognize the principles of soils.

11-71. A poor foundation eventually causes roads, runways, buildings, and other temporary or permanent structures to collapse.

1. True
2. False

11-72. What soil layer is lighter in color and is composed of sand, gravel, silt, and clay?

1. A-horizon
2. B-horizon
3. C-horizon
4. D-horizon

11-73. Which of the following soils has good load-bearing qualities and drains freely?

1. Organic
2. Fine grained
3. Medium grained
4. Coarse grained

11-74. Which of the following advantages are reasons soil stabilization is important?

1. Strength improvement
2. Dust control
3. Soil waterproofing
4. All of the above

11-75. When computing the amount of cement required for a soil stabilization project, you should use what rule of thumb?

1. One 50-pound bag for every cubic yard
2. One 50-pound bag for every square yard
3. One 50-pound bag for every cubic feet
4. One 50-pound bag for every square feet

ASSIGNMENT 12

Textbook Assignment: “Earthwork Operations,” and “Paving Operations and Equipment,” pages 15–37 through 16–44.

Learning Objective: Recognize the techniques of earthwork operations.

12–1. Which of the following is NOT a factor when determining the methods of earthwork operations required for a project?

1. The acreage to be cleared
2. The availability of water to achieve optimum moisture content
3. The type and density of vegetation
4. The expected weather conditions

12-2. Equipment production rates are obtained from which of the following NAVFAC publications?

1. P-300
2. P-306
3. P–404
4. P-405

12-3. What term is used to describe a construction operation that consists of cleaning a designated area of trees, timber, brush, and rubbish?

1. Clearing
2. Grubbing
3. Stripping
4. Grading

12–4. What term is used to describe a construction operation that consists of removing and disposing of objectionable topsoil and sod?

1. Clearing
2. Grubbing
3. Stripping
4. Grading

12-5. What factor(s) must be considered when designing and building a road?

1. Type of drainage
2. Type of soil
3. Amount of clearing and grubbing
4. All of the above

12-6. Optimum moisture content must be maintained when compacting lifts of base course materials.

1. True
2. False

Learning Objective: Recognize the principles of pavement construction.

12-7. What was the primary reason for the rapid growth in the construction of asphalt road surfaces in the late 1800s?

1. The need for large airport runways
2. The cost of asphalt was cheaper than concrete
3. The emerging automotive industry
4. Asphalt was the only means available for hard-surface paving

12-8. A pavement is only as good as the materials and workmanship that goes into it.

1. True
2. False

12-9. Both rigid and flexible paving consist of which of the following materials?

1. Sand and gravel
2. Crushed stone
3. Binder
4. All of the above

12–10. In addition to the asphalt content, what other factor determines the principal characteristics of asphalt -paving mixes?

1. The total weight of both the asphalt content and aggregates
2. The relative amount of aggregates
3. The largest size aggregate used
4. The type of roadbed the asphalt is used on

12–11. Asphalts are produced from refineries in many types and grades. The one known as asphalt cement is the basic material used in asphalt paving and is produced in which of the following conditions?

1. Hard
2. Brittle
3. Semisolid
4. Water thin

12–12. Which of the following properties is essential for an asphalt-wearing surface?

1. Retention of antiskid properties
2. Resistant to wear
3. The capability to shed surface water
4. All of the above

12–13. What term is used to describe the operation of adding more layers of asphalt to a pavement to increase its weight-bearing surface?

1. Surface treatment
2. Asphalt addition
3. Stage construction
4. Subgrade elevation

12-14. A load-bearing test commonly used by the Seabees is the CBR test. What does CBR represent?

1. Course base repair
2. California bearing ratio
3. California base rate
4. Cold-bearing rate

Learning Objective: Recognize the principles of preparing asphalt for construction operations.

12-15. Asphalt cement can be made temporarily fluid (liquefied) for construction operation in what three ways?

1. Emulsifying with water, melting, and crushing
2. Melting, dissolving, and crushing
3. Heating, dissolving, and emulsifying
4. Crushing, heating, and dissolving

12-16. The aggregate and binder of a hot-mix paving mixture should be heated to what temperature, in degrees Fahrenheit?

1. 110°F
2. 200°F
3. 310°F
4. 400°F

12-17. Blue smoke rising from the spreader hopper is often an indication of which of the following asphalt conditions?

1. The mix is overheated
2. The mix is too cold
3. The mix is too rich
4. The mix is too lean

12-18. What functions does a prime coat of bituminous material serve?

1. The prime coat penetrates the base course about 2 inches, fills most of the voids, and promotes adhesion between the base and previous bituminous applications
2. The prime coat penetrates the base course about 1/4 inch, fills most of the voids, promotes adhesion between the base and bituminous applications placed on top of it, and waterproofs the base
3. The prime coat waterproofs the wearing surface and controls dust and loose aggregates
4. The prime coat increases compaction and binds the aggregates and fines together

12–19. An underprimed area can be corrected by performing which of the following operations?

1. Applying twice the amount of prime material
2. Applying a layer of sand, then repriming over it
3. Applying twice the thickness of asphalt over the underpriced area
4. Applying a second coating of the prime material

12–20. What is an indication that the base course is overpriced?

1. A free film of prime material remains on the base after a 45–hour curing period
2. The area looks dry and dark after a 24–hour curing period
3. A free film of prime material remains on the base after an 8–hour curing period
4. The area looks and feels damp after a 12–hour curing period

12-21. A tack coat is an application of asphalt to an existing paved surface that provides a bond between which of the following surfaces?

1. The subsurface and subgrade surface
2. The finish surface and the subgrade surface
3. The existing surface and the asphalt material to be placed on it
4. The subsurface and the base surface course

12–22. An area that has an excess of tack coat material can be corrected by taking which of the following actions?

1. Apply heat until the excess bitumen drys
2. Spread clean, dry sand on the area
3. Skip over the area and pave it last
4. Dig up the area and replace the material

Learning Objective: Recognize the types of asphalt pavement construction.

12-23. What is the major difference between plant-mix construction asphalt and mix–in–place construction asphalt?

1. The type of asphalt and aggregate used in plant-mix construction is much heavier and stronger than that used in mix–in–place construction asphalt
2. Plant-mix construction asphalt requires a different rolling technique
3. Plant-mix construction asphalt is prepared in a central mixing plant
4. Plant-mix construction asphalt requires a different curing time

12-24. When computing plant-mix materials, you use what pound value to represent the approximate weight of 1 cubic foot of compacted hot-mix asphalt?

1. 80 pounds
2. 100 pounds
3. 120 pounds
4. 146 pounds

12-25. When you are performing asphalt hand spreading operations, what problem can result if you throw the material a long distance or dump it from too great a height?

1. The hot-mix will cool too fast
2. The hot-mix will splatter all over the place
3. The hot-mix will segregate
4. The hot-mix will fail to bind with the mix placed on the ground

12-26. What is the most important phase of flexible pavement construction?

1. Compaction
2. Mixing
3. Paving
4. Transporting

12-27. What is an advantage of mixed-in–place construction?

1. It takes less time and skill to work with
2. It retains a higher road-bearing ratio
3. The aggregate is already on the roadbed or available from nearby source
4. The asphalt is less expensive and can be laid in cold weather

12-28. A single layer of road-mix pavement normally has what thickness, in inches?

1. 1/2 to 1
2. 1 to 1 1/2
3. 1 1/2 to 3
4. 3 1/2 to 4 1/2

12–29. “Surface moisture” is defined as

1. the depth of puddling water
2. the film of water around each particle of stone or sand
3. the estimated number of gallons of water a road surface can hold
4. the amount of moisture that collects on a road surface during early morning hours

12–30. A uniform mix controls the rate of travel and mixing operation of a travel mix plant.

1. True
2. False

12-31. When performing blade–mixing operations, you should apply what total number of equal applications of bitumen with a bituminous distributor?

1. Two
2. Three
3. Four
4. Five

12–32. The bituminous mix should be spread when the surface is damp or when the mix itself contains an excessive amount of moisture.

1. True
2. False

Learning Objective: Recognize the defects and techniques of repairing flexible pavements.

12–33. Which of the following types of surface cracks is caused by excessive movement of the surface over unstable subgrades or base courses?

1. Alligator
2. Edge
3. Reflection
4. Slippage

12–34. Which of the following types of surface cracks is caused by a lack of bond between the surface layer and the course beneath?

1. Alligator
2. Edge
3. Reflection
4. Slippage

12–35. What type of surface defect results from either compaction or a movement of the subgrade soil that weakens the subgrade?

1. Cracking
2. Distortion
3. Disintegration
4. Melting

12-36. What type of surface defect results from the localized upward displacement of the pavement caused by swelling of the subgrade?

1. Channeling
2. Corrugation
3. Depression
4. Upheaval

12–37. Which of the following types of surface defects is usually the result of a rich plant mix or a prime or tack coat that was placed too heavy?

1. Polished aggregates
2. Raveling aggregates
3. Bleeding aggregates
4. Rolling aggregates

12-38. Repairs performed on flexible pavements must start at the source of the failure.

1. True
2. False

12–39. When you are performing pavement-cutting operations for patchwork, the cut should extend to at least what depth in the good pavement?

1. 1 foot
2. 2 foot
3. 3 foot
4. 4 foot

12–40. When placing a hot mix in a patch, you should overfill the area by approximately what percentage over the required pavement thickness?

1. 10%
2. 20%
3. 30%
4. 40%

Learning Objective: Recognize the principles of surface treatment.

12–41. Of the following improvements, which is gained by applying a surface treatment?

1. It waterproofs the surface
2. It provides a wearing surface
3. It prevents hydroplaning
4. All of the above

12–42. What is the liquid asphalt rate of application (ROA) when performing dust–laying operations?

1. 0.1 to 0.5 per square yard
2. 0.1 to 0.5 per square feet
3. 0.1 to 0.5 per cubic feet
4. 0.1 to 0.5 per cubic yards

12–43. When performing single-surface treatment operations, you should push the aggregate into the bituminous material using what type of roller?

1. A towed grid
2. A vibratory steel drum
3. A pneumatic–tired
4. A vibratory sheepsfoot

12-44. When performing single-surface treatment operations, you should ensure aggregates cover the bituminous material within how many minutes after spraying?

1. 1 minute
2. 10 minutes
3. 30 minutes
4. 60 minutes

12-45. To compute the amount of aggregate per square yard required for a single-surface treatment, you use what rule of thumb?

1. 10 to 15 pounds per square yard
2. 15 to 25 pounds per square yard
3. 25 to 30 pounds per square yard
4. 30 to 35 pounds per square yard

12-46. What size of aggregate is used on the second layer of a multiple-surface treatment?

1. 1/2 the size of the previous layer
2. 3/4 the size of the previous layer
3. 1 1/2 the size of the previous layer
4. 1 3/4 the size of the previous layer

Learning Objective: Recognize the principles and components of paving equipment.

12-47. Of the following disadvantages, which is associated with the use of a tailgate spreader?

1. The truck must be operated in reverse
2. A reduction in steering control of the truck
3. A reduction in the operational speed of the truck
4. All of the above

12-48. Which of the following components is NOT part of an asphalt distributor unit?

1. Insulated storage and heating tank
2. Open-flame heating system and asphalt pump
3. Low-pressure air blower and circulating and spraying system
4. Twin-shaft pugmill that thoroughly mixes the material

12-49. Asphalt heating operations can be performed while the distributor truck is traveling to the jobsite.

1. True
2. False

12-50. When spraying bitumen with a distributor truck, the application rate is controlled by the length of the spray bar, the pump output, and what other factor?

1. Amount of material carried
2. Existing ground material
3. Forward speed of the distributor truck
4. Amount of turns on the main control valve

12-51. When operating a distributor truck, the spray bar should be set high enough for the road surface to receive triple coverage. However, under heavy wind conditions or depending on the nozzle spacing, it may be necessary to lower the spray bar more to ensure the surface receives which of the following coverages?

1. Single
2. Double
3. Triple
4. Half

12-52. When heating bitumen in a distributor truck, you should NOT use which of the following fuels?

1. Kerosene
2. Fuel oil
3. Diesel
4. Gasoline

12-53. Before the burners are lit on a distributor truck, the flues must be covered by a total of how many inches of material?

1. 3 inches
2. 6 inches
3. 9 inches
4. 12 inches

12–54. Which of the following actions should you take to prevent the distributor pump and circulation system from clogging up because of bitumen setting up and hardening in the system?

1. When used, you should flush out the pump and circulating system at the end of the day
2. Flush out the pump and circulating system at least once a week
3. Wash the outside of the pump with solvent weekly
4. Circulate bitumen through the pump daily

12–55. What is the storage capacity of an asphalt kettle?

1. 15 gallons
2. 50 gallons
3. 100 gallons
4. 165 gallons

12–56. Which of the following conditions can develop if emulsified asphalt is left in a distributor truck for any great length of time?

1. The emulsified asphalt can become highly flammable
2. The emulsified asphalt will separate and set in much less time than cutbacks
3. The emulsified asphalt will expand and damage the tank
4. The emulsified asphalt will evaporate resulting in the loss of material

12–57. To prevent sticking, you must take what action to prepare the bed of a dump truck before loading hot–mix asphalt into it?

1. Spray the bed with water
2. Lay a light coat of sand in the bed
3. Coat the bed with a release agent (lubricant)
4. Lay a plastic covering in the bed

12–58. Which of the following factors should be considered when planning the number of trucks required for an asphalt plant?

1. The mix production rate of the plant
2. The length of the haul
3. The type of traffic encountered
4. All of the above

12-59. An end–dump truck must be inspected to ensure the rear of the dump bed overhangs the rear wheels enough to discharge the hot-mix asphalt into the paver hopper. If the dump bed does not, what action should you take?

1. Do not use the truck
2. Shovel the material by hand into the hopper
3. Add an apron with side plates to increase the overhang of the dump bed
4. Raise the dump bed only halfway

12-60. When positioning a dump truck to dump a hot-mix asphalt into a paver, you must ensure the truck is squarely against the paver and the truck tires are in what position in relation to the roller bar on the paver?

1. A few inches away
2. Squarely against the roller
3. At least 1 foot away
4. Bumped against the roller bar

Learning Objective: Recognize the principles of asphalt finishers (pavers).

12-61. The primary job of an asphalt paver is receiving and spreading asphalt in a predetermined uniform length, width, thickness, and shape.

1. True
2. False

12-62. Hot-mix asphalt that is dumped in the hopper is transported to the distributing augers in what way?

1. It is carried by the vibrating screed
2. It is pushed by the tamper bar
3. It is pushed by the bevel end plates
4. It is carried by the feed conveyor

12-63. During paver operations, which of the following conditions can cause unnecessary movement of the paver that is transmitted to the screed and results in an uneven pavement surface?

1. Low tire pressure or loose crawler tracks
2. The screed is too hot
3. The vibratory unit is not set properly
4. Oversteering by the operator

12-64. A paver engine is not working properly and a power lag occurs that causes a temporary failure of the vibrators or tamping bars in the screed unit. What condition results from this failure?

1. A stretch of pavement that is less dense or contains slightly less material
2. A stretch of pavement that has more material
3. The fines in the asphalt mix separate
4. The asphalt mat is higher in that area after it is rolled

12-65. During operations, the speed of the conveyor and the opening of the control gates at the back of the hopper of the paver should be adjusted to allow just enough mixture to be delivered to the augers so they are operating what minimum percentage of the time?

1. 65%
2. 75%
3. 85%
4. 95%

12-66. What component of the asphalt paver irons the asphalt mixture surface, leaving the hot mat thickness at a depth that conforms with job specifications?

1. The screed
2. The tamper
3. The conveyor
4. The hopper

12-67. Tamping bars and vibratory mechanisms are designed to perform which of the following functions?

1. Strike off and heat the asphalt
2. Strike off and adjust the amount of asphalt
3. Strike off and compact the asphalt
4. Strike off and roll the asphalt

12-68. What condition results if the tamping bar travels too far downward below the screed plate on a tamping bar type of screed?

1. The hot-mix builds asphalt upon the screed face and this condition tends to scuff the surface of the mat
2. The hot-mix asphalt decreases in thickness and the surface pits
3. Overcompaction occurs resulting in too thin of a mat
4. The tamper over compacts, crushing the aggregate and causing the mat to break apart

12-69. On a vibrating type of screed, the compactive force can be generated by hydraulic motors, rotating shafts with eccentric weights, or by electric vibrators.

1. True
2. False

12-70. When an adjustment is made to the screed control of a paver, the effect of the adjustment can be seen after the paver travels what distance?

1. Several yards
2. Several inches
3. Several feet
4. Several meters

12-71. Poor pavement smoothness is most likely a result of which of the following operator errors?

1. Paving too fast
2. Over thickness control
3. Paving too slow
4. Overcompaction

12-72. The screed plates on an asphalt paver have a total of how many screed crown adjustments?

1. One
2. Two
3. Three
4. Four

12-73. For paving operations, a paver screed should be heated at what time ?

1. During the paving operation
2. Before the paving operation
3. Only sometimes during the paving operations
4. Only when asphalt materials are under the screed

12-74. Which of the following components are commonly used screed accessory attachments?

1. Screed extensions
2. Cutoff shoes
3. Bevel end plates
4. All of the above

12-75. The required tonnage of hot-mix asphalt for a project is 1500 tons. The screed of the paver is set at 8 feet, and the depth of asphalt is 4 inches. What is the amount of asphalt that can be laid per hour?

1. 80.46 tons
2. 100.62 tons
3. 128.35 tons
4. 192.72 tons

✩ U.S. GOVERNMENT PRINTING OFFICE: 1994 — 633-130/20008